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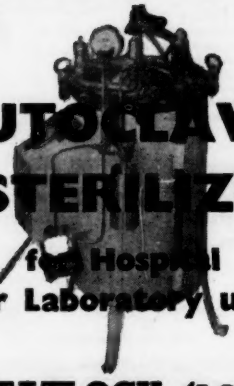

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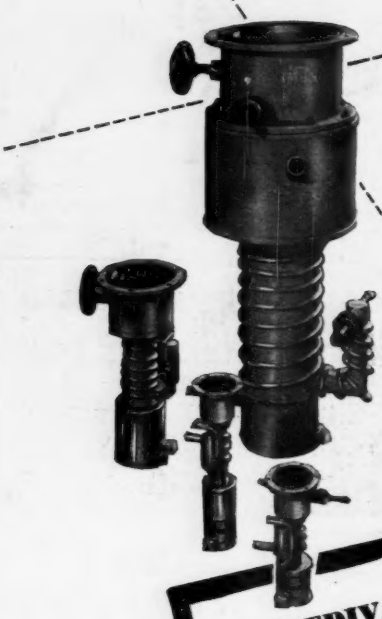

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NATURE

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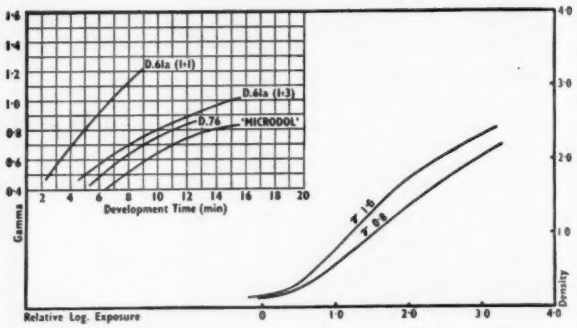

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SCIENTIFIC AND TECHNICAL MAN-POWER FOR UNDEVELOPED TERRITORIES

A DEBATE in the House of Commons on the Supplementary Estimates on March 16 took place on a motion to provide a further £300,000 in the year ending March 31, 1955, for grants-in-aid of expenses of the United Nations and of technical assistance for economic development. During the debate, the report on visits to the Technical Assistance Administration of the United Nations and to the Food and Agriculture Organization issued by the Federation of British Industries* was freely quoted and warmly commended both by Mr. Cyril Osborne, who opened the debate, and other speakers, and by the Joint Under-Secretary of State for Foreign Affairs, Lord John Hope, who replied for the Government. The report points out that Britain has a special understanding of the benefits which flow from the injection of capital and of technical and managerial skills into less-developed areas of the world. "To those areas themselves, it brings the opportunity of developing natural resources, of earning higher incomes, of securing a higher standard of life. To the more developed countries, it brings access to raw materials and a growth of trade."

All this, of course, as the report duly notes, is a great influence for peace, though naturally the Federation directs attention to the opportunities which potential improvements in agriculture provide for industrial products when half the world's acreage is still reaped with the sickle. Furthermore, technical assistance brings to underdeveloped countries the benefits of modern knowledge of nutrition and of the control and prevention of disease. But the report also gives warning that the consequent rapid growth in population may result in a lowering of the standard of living, unless it is accompanied by an immense increase in the production of food.

Perhaps the most interesting general feature of this report is, in fact, the demonstration of firm support for the Technical Assistance programme from industrialists, who frankly admit, as a result of their visits, their surprise that they know so little of what is going on. The Federation of British Industries is satisfied that the concept of technical assistance is right on broad humanitarian grounds and, in general, politically and economically sound. It has no doubt that much is done that is very good, that administrative efficiency is improving, and that many seeds are planted, some of which will germinate. It commends to British consulting engineers, contractors and manufacturers the desirability of maintaining closer touch with this work; but it was dissatisfied with the United Kingdom liaison arrangements and indicated that ideas for improving these arrangements had arisen which it was proposed to discuss with the authorities.

Lord John Hope, who stated that from the inception of the Expanded Technical Assistance programme in 1950 up to June 30, 1954, £1,889,000 had been spent in the United Kingdom and £2,035,000 had been contributed by the United Kingdom, said that the Government would do its best to see that the programme is made as widely known as possible. There are, however, two further features of the report, both of which were stressed in the debate, that are of special importance. First, the report emphasized the importance for efficient administration of knowing in advance the scale on which its activities can be pursued. In the absence of such knowledge, for example, the staff position is insecure and good men are deterred from accepting posts. The report regards it as unfortunate that pledges by governments of their financial support for the following year are given so late as November. Believing that technical assistance is good policy and that it should be given the chance to be administered efficiently, the Federation specifically urges the Government to give a lead by announcing the scale of support it will give to the Expanded Programme for at least two years ahead, subject to Parliamentary approval.

On this point Lord John Hope declined to commit the Government, though he did not exclude the possibility of representations to the Treasury; and he referred to the example which Britain has set in the related and important matter of promptitude of payment. What he said in regard to the second point was, however, even more important. The report expresses the hope that British policy will provide for increasing the participation of the United Kingdom in this work, both financially and operationally, and in particular states its opinion that there are many technical assistance projects for which the offer of really good experts from the United Kingdom is most desirable, and urges all concerned to be readier to release men in such efforts. Lord John Hope's reply here helped to put the whole question in its proper perspective. The limiting factor, he reminded the Committee, is not so much the amount of funds as the availability of experts. Even now we are ahead in the field, and have produced more experts to help in this work than any other country. Nevertheless, as the Secretary of State for the Colonies told the House of Commons on February 2, in the debate on the second reading of the Colonial Development and Welfare Bill, there is already a grievous shortage of trained people; and there is a distinct possibility that an even greater shortage of scientific and technical experts and of trained administrators may frustrate plans for development and welfare in Nigeria and elsewhere in Africa. On his recent visit

* United Nations Technical Assistance: Report on visits to the Technical Assistance Administration of the United Nations in New York, in September 1954, and to the Food and Agriculture Organisation in Rome, in October 1954. Pp. 38. (London: Federation of British Industries, 1955.) 2s. 9d.

to Nigeria, he found that it is generally recognized that development and welfare depend on the availability of administrative and technical experts; and recent events in the Sudan have at least indicated that, even if the men can be found, they will not be available unless the appropriate conditions are provided.

This, of course, is a question that has two sides; but even where in the backward areas conditions of trust and esteem encourage technical experts from the more advanced areas to come forward and help, there is for consideration also the question whether long-term interests are not best served by training nationals for those areas in the universities and technical colleges and other institutions of the advanced countries. In the present man-power situation, indeed, it may be the only possible policy for such a country as Britain to adopt in order to avoid the dispersal of resources to the point where they become ineffective. Mr. Nehru, for example, is reported to have requested the services of a large number of British physicists for the development of nuclear energy in India. Even without regard to the proportion of Britain's scientific effort already deployed in this field, it may well be argued that Britain can best serve India in this field by providing the training places at Harwell and elsewhere, in accordance with the policy announced even before the White Paper on nuclear power was published. Sir Edward Appleton, indeed, has suggested that in view of the man-power situation it would be preferable to concentrate upon building the nuclear energy plants in Great Britain; but that involves other and more debatable assumptions, although the possibility was envisaged by Lord Salisbury in speaking of the nuclear power programme in the House of Lords on February 15.

It was a welcome feature of the debates on the second reading of the Colonial Development and Welfare Bill, both in the House of Commons and later in the House of Lords on February 24, that due weight was given to this question of scientific and technical man-power. Mr. Lennox-Boyd frankly recognized that the limits of expenditure are set largely by the shortage of trained men. In fact, the figure of £80 million new money for the period 1955–60 proposed in the Bill, making, with the unspent £40 million of the existing provision, a total of £120 million, as foreshadowed in the recent report on the administration and use of the funds provided under the Colonial Development and Welfare Acts*, was arrived at after examining the outline forecasts of the Colonial Governors in the light of such physical limits to development. This money, which the Earl of Munster said represents an increase of 70 per cent over actual expenditure in the previous quinquennium, is not, of course, the only source of funds for Colonial development and welfare. In fact, Mr. Lennox-Boyd estimated the total investment in British Colonial territories by the United Kingdom and the Colonial governments as some £600 million, excluding expenditure in the Central African Federation and certain large schemes such as the Volta River Scheme.

In these circumstances the question of priorities becomes all-important, and it should be the easier to determine the right priorities and secure adequate support in executing them now that there is such general agreement on the shortage of technical skill at all levels. Mr. James Griffiths, for example, fully agreed with all that Mr. Lennox-Boyd had said on this point, and added that in all the provisions we have made for technical assistance we should make it clear that our purpose is to train indigenous technicians as quickly as possible. Mr. Griffiths, and Sir Roland Robinson, who followed him, welcomed the provision to be made everywhere for extended technical education, as did Mr. Thomas Reid, while Mr. John Tilney referred to the bearing of this on agricultural production and to the need for more mobility on the part of administrators. With the changing conditions in different parts of the world, he suggested that it might be possible to provide continuous service for a corps of highly qualified administrative officers, though not necessarily always in the same territory or the same part of the world, and that this is perhaps a problem which Britain should tackle, not alone but in co-operation with other Western countries.

Clearly that is a suggestion that bears closely on the supply of scientific and technical experts and their most efficient use, and it reminds us also of the extent to which the problems of man-power in Colonial development and welfare are interlocked. It is not simply a matter of deciding whether social or economic development should have priority. As Mr. Philips Price pointed out, we cannot get satisfactory training for Africans until we have enough entrants into the training colleges, and that in turn depends on getting enough teachers for the primary schools. We have thus to start with fundamental primary education, and while it may well be true, as Mr. Ian Winterbottom remarked, that the most significant thing Britain has done as a Colonial Power is the creation of five university colleges, the need for education generally is, as the White Paper emphasizes, the greatest and most urgent of social and welfare needs; and it has already absorbed some £21·4 million of Colonial Development and Welfare Funds, of which £11 million has gone to university, technical and vocational education.

One suggestion made in this debate, by Mr. P. Williams, was that some attempt should be made to influence the balance of studies among students coming to Britain in the direction of engineering, agriculture, and other fields where experts are most needed, as against law and other professions not of such primary importance. The other major suggestion, made by Mr. A. Creech Jones, was that more care should be taken to avoid piecemeal schemes in Colonial development, and that it might prove possible to associate the economies of the Colonial Territories more closely with that of Britain. That, of course, is essentially the idea behind technical assistance and the Point Four Plan, and the report

* Colonial Office. Colonial Development and Welfare Acts. Report on the Administration and Use of the Funds provided under the Colonial Development and Welfare Acts. Pp. 32. (Cmd. 9375.) (London: H.M. Stationery Office, 1955.) 1s. net.

on the Colonial Development and Welfare Acts, like the annual report on Colonial research or on the Colonial territories, shows that much is already being done in this direction. Indeed, for those familiar with the latter reports, there is no need to recapitulate the admirable summary of the working of the Acts contained in this recent report.

Much has already been done to co-ordinate research activities and to avoid duplication of effort in the Colonial territories and in the United Kingdom, while pools of scientists, based on the appropriate United Kingdom scientific institutions, have also been formed to provide expert advice to Colonial governments on specific problems. It may be, however, that something more is yet required in order that the limited man-power at our disposal may be deployed most advantageously and effectively from the Commonwealth point of view. Shortage of man-power is not the only reason for difficulty in obtaining the right men. Lord Ogmore, indeed, suggested that the chief reason for that difficulty is that technicians and professional men have become rather chary of taking service in some Colonial territories that have acquired a measure of self-government. He also referred to the hope expressed by Ministers of the Northern Nigerian Regional Government that administrators and technical officers released and available from the Sudan would find important opportunities for service in Northern Nigeria. While Ministers in other territories also might welcome an increasing flow of technical assistance in this and other ways, that flow would certainly be facilitated by the formation of an international or Colonial cadre or pool such as has been suggested. Possibly it would prove easier also to adjust the British contribution to the competing demands made on Britain's scientific and technical man-power. Lord Tweedsmuir also touched on a point of critical importance in this connexion. In spite of the great demand for the best men in the United Kingdom, it is remarkable how seldom experience in the Colonial territories is of assistance in obtaining employment in Britain. Under present conditions, there must be the opportunity of returning to Britain, or the outflow of technical experts will dwindle long before the facilities for technical education in the Colonies have developed sufficiently for the territories themselves to provide the technicians they require. Quite apart from this, the scientific and technical expert returning from the Colonial territories or some other underdeveloped part of the world can make an important contribution towards educating the community in Britain to understand the needs and problems of the Colonial territories. Considerable as may be the difficulties in developing even a Commonwealth service, much more an international service, the attempt is worth making, nor would it appear that financially the cost of doing so should be excessive. No actual figures were quoted in the debates or in the White Paper, except that the Earl of Munster gave 452 as the number of research officers now employed by the Colonial Office.

Even allowing for the present serious shortage of qualified scientists and technologists and the competing calls of industry and other government departments, it would not appear that, when a reasonable balance has been struck between supply and demand, the numbers of scientists and other technical experts involved need be very large. The debates, however, give further point to the inquiry into the use of scientists and technologists now being made by the Government and which the Federation of British Industries has suggested to its own members. It emphasizes also the urgency of measures for dealing effectively with the shortage of science teachers both in the short term and in the long run; and above all the importance of taking stock at a high level of the implications of Colonial development and welfare and technical assistance in general for the scientific and technical man-power of the United Kingdom.

TROPICAL SOILS AND THEIR ORIGINS

Tropical Soils

A Critical Study of Soil Genesis as Related to Climate, Rock and Vegetation. By Prof. E. C. J. Mohr and Prof. F. A. Van Baren. Pp. 498+4 plates. (The Hague and Bandung: N.V. Uitgeverij W. Van Hoeve; London: Interscience Publishers, Ltd.; New York: Interscience Publishers, Inc., 1954.) 61*s*.

THIS new text-book on tropical soils, beautifully printed and well illustrated, reminds one in many places of Prof. E. C. J. Mohr's well-known treatise, "The Soils of the Equatorial Regions, with Special Reference to the Netherlands East Indies", which is one of the earlier classics of tropical soil science. As the title of the present book indicates, it follows the developmental trend: soils are the result of the interaction of external factors and parent materials. As is pointed out in the introduction, consideration has only been given to those essentials which have some direct bearing on the problem. Subjects such as erosion, fertility, irrigation and drainage have deliberately been avoided, unless they have a direct influence on the soil formation; these subjects, it is stated, will be dealt with in a second volume, to be entitled "Tropical Soils and Crops".

Both authors spent several years studying soils in the former Dutch East Indies, so it is only natural that much of their factual evidence consists of Indonesian climatological and pedological data, which are both rather specialized. Indeed, on the South American and African continents, which make up most of the tropical soils of the world, maritime climatic conditions are very limited, and volcanic parent materials are not so common. On the other hand, it is a fact that, until very recently, the better-known tropical regions were those easily accessible from the sea, and the best-known soils there were the more fertile patches that are often derived from volcanic or closely related basic material. It must be admitted that not many tropical countries can offer such a wealth of accurate information as Indonesia.

Of all the pedogenetic factors involved, the authors attach by far the most importance to climate and parent material. The opening chapter, which is devoted to climate, comprises about one-fifth of the whole work, and this and the following six chapters,

dealing with rocks, their composition, their catamorphism under tropical conditions and their weathering products, complete more than half the book. Chapter 7 (twenty pages) is the only one entirely devoted to organic matter; then three chapters on genetic conceptions of soil formation, and five chapters in which a number of better-known tropical soils and their classification are discussed, complete the volume. One might conclude from this that the book shows some serious gaps. One must not forget, however, that this is a 'critical' study, and that, of the limited material available, probably much had to be discarded. Tropical soil science is still in its early stages, and the apparently neglected fields are, in fact, those that cry out most urgently for more investigation, as the authors frequently suggest. Apart from these few criticisms, the book is, in my opinion, a very good introduction to the subject for students in tropical soils.

In the first chapter, a selection of meteorological data from different regions of the world gives a fine illustration of typical tropical climate characteristics, such as rainfall distribution, different types of rainfall, rain intensity and dew formation. Reference is given to recent work by Thornthwaite and Penman on evaporation and evapo-transpiration. The rational classification of world climates, as proposed by the former author, receives only little space, but attention is redirected to Mohr's earlier classification, based on the number of wet (more than 100 mm.) and dry (less than 60 mm.) months.

The chapters devoted to rocks, their weathering and weathering products begin with a good review of fundamental soil mineralogy. While discussing the specific influence of climate on rocks, it is pointed out first that the present-day overhead climate is a much over-estimated factor and then that the grouping of tropical soils on a climatic zonal basis will inevitably be attended by various intricate complications. This statement is very pertinent, especially for the African continent, where more and more evidence is being gathered for very recent climatic variations. The chapter specifically devoted to tropical rock weathering gives a review of the more serious work done on this most promising subject, and is followed by a discussion on clay mineral formation.

As Prof. F. A. Van Baren is an authority on mineral associations in volcanic soils, a good outline is given of mineralogical work on such material. In young soils, such as volcanic ashes, this study may indeed be of real diagnostic significance for assessing the potential fertility; for older soils, the study of unalterable minerals may provide some indication as to the parent materials from which they were derived. To the discussion of granulometric data, one might add the two rather striking features found all over Africa in many old soils: the low percentage of silt-size minerals; and the presence of what might be called 'pseudo-silt' or silt-size water-stable aggregates of finer material, cemented by iron or aluminium oxides.

In their developmental conception of soil formation, the authors consider temperature, water movement, air in the soil, time and weathering stages, parent material and organic matter as the principal distinguishing features of tropical weathering. By translating each of these into a number of symbols, a given soil can be represented by what the authors call a "genetic formula"; for example, *Vb, Ho, DD, ae* means a soil formed from basic volcanic material, deposited in hot wet lowlands, with continually descending water movement, and well aerated. This genetic conception is then applied to the different Indonesian soils, mostly of volcanic origin. This part of the book is a most valuable contribution to the study of tropical volcanic soils, and sets a pattern for future work on similar soils in other parts of the tropical world.

A good and up-to-date chapter on laterite and lateritic soils is followed by a shorter one on the still much-discussed tropical podsols. Another is devoted to the so-called Margalitic soils, a name proposed for grouping the black tropical and subtropical soils, hitherto designated under various names, ranging from black cotton soils to Regur, Rendzina and Tirs. Many of these soils are still badly defined, but several seem to have a great potential fertility if properly treated. Finally, the authors discuss a series of soils, most of them also ill-defined, known as desert soils, alkali soils, steppe and savannah soils, plain soils, plateau soils, hardpan soils, limestone soils and Ando soils. In the final chapter, devoted to soil classification, the authors discuss some of the older classification systems, including Milne's catena conception. They give their opinion on nomenclature and on the different ways of describing tropical soils. According to them, high priority should always be given to the genetic trend when establishing a general classification system; the climatological grouping of zonal, intrazonal and azonal should be dropped, the terms 'type' and 'series' should be reconsidered, and profile types should be used as basic units for classification purposes.

This book can be warmly recommended; but it is to be hoped that in a new edition more attention will be given to pedological work in Africa, where great progress has been made during the past ten years, as may be seen from the increasing number of papers in English, French and Portuguese now available.

J. D'Hoore

MATHEMATICAL ANALYSIS

Theory of Functions of Real Variables

By Prof. Henry P. Thielman. (Prentice-Hall Mathematics Series.) Pp. xiii+209. (London: Butterworths Scientific Publications, 1953.) 35*s*. net.

Principles of Mathematical Analysis

By Walter Rudin. (International Series in Pure and Applied Mathematics.) Pp. ix+227. (London: McGraw-Hill Publishing Company, Ltd., 1953.) 40*s*.

THE distinctive features of Prof. H. P. Thielman's book, "Theory of Functions of Real Variables", which is intended to follow a course in advanced calculus, is the emphasis on the postulational approach and on the theory of sets. The first chapter treats positive integers as defined by Peano's postulates and proceeds to rational, irrational, algebraic and transcendental numbers, discussed in relation to sets, groups and fields. Then follow three very lucid chapters containing a good deal of information about sets and abstract spaces. Chapters 5 and 6 deal with functions on sets, and with a discussion of limits and continuity in connexion with Hausdorff spaces. Chapter 7 is more elementary than the rest of the book. It gives the usual tests for convergence of infinite series, which are generally studied at an earlier stage. Chapters 8 and 9 give a clear exposition of measure and of integration in the sense of Riemann,

Lebesgue, Riemann–Stieltjes and Lebesgue–Stieltjes. Finally, Chapter 10 discusses absolute continuity, the indefinite integral over sets, and derivates. There are about two hundred problems distributed through the text. In order to cover as much ground as possible, the author has relegated many minor theorems to this set of problems to be solved by the student. Presumably, if the student cannot himself supply the proofs of these minor theorems, he must refer to the larger treatises recommended at the ends of several chapters. The book concludes with a copious index.

Dr. W. Rudin's "Principles of Mathematical Analysis" has much in common with Prof. Thielman's book, and covers, more concisely, nearly the same ground, with some additions. However, Dr. Rudin claims that, except for a few facts about determinants, his treatment is self-contained, the main requirement being the reader's ability and inclination to pursue an abstract train of thought. The first chapter deals with the real and complex number systems. Chapter 2 compresses the elements of set theory into eighteen pages. The simpler properties of the convergence of real and complex sequences and series are given in Chapter 3. Subsequent chapters, except for a brief reference in Chapter 6, deal only with the real variable. Chapter 4 discusses limits and continuity, and Chapter 5 the mean value theorem and related theorems, including Taylor's. Chapter 6 introduces the Riemann–Stieltjes integral, while Chapters 7 and 8 return to the discussion of series, and include uniform convergence, equicontinuous families, Fourier series, and some recent work by Stone generalizing a theorem of Weierstrass. Chapter 9 gives some of the leading theorems about functions of several variables, including a discussion of Jacobians and functional dependence. Chapter 10 gives an unusual treatment of Lebesgue integration, based on an additive set function—a generalization of the usual Lebesgue measure—in a space more general than that usually considered. It is claimed, not altogether convincingly, that this departure from the usual treatment brings out the essential features with greater clarity.

There are more than a hundred and thirty miscellaneous problems at the ends of the chapters, with hints for the solution of the more difficult. Simpler examples occur in the text, including some which show how theorems just proved may fail if the conditions are relaxed. The book concludes with a short bibliography, a list of symbols and an index. It has many merits for sufficiently mature students.

H. T. H. Piaggio

MODULATION AND INFORMATION THEORY

Modulation Theory

By Harold S. Black. (The Bell Telephone Laboratories Series.) Pp. xii+364. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1953.) 65*s*. net.

THIS book is a recent addition to the Bell Telephone Laboratories series and is, in fact, the twenty-eighth volume of the series. The term modulation has come to represent in the most general as well as in the most specific sense any process whereby a message is translated into information-bearing signals for purposes of transmission and by which the signals reproduce the message at the receiving end. Direct long-distance communication became practicable with the development of the science of electromagnetism, and the theory and practice of modulation in the sense in which the term is used to-day thus began with telegraphy a little more than one hundred years ago. Some of the concepts now recognized as having fundamental significance appeared quite early in the history of telegraphy; but it was not until radio and multi-channel line communication were beginning to establish themselves on a major scale in the early 1920's that the quantitative generalizations which now form the basis of communication theory began to be enunciated. With the increasing practical importance of the effect of 'noise' on communication resulting from the power to amplify to an almost unlimited extent, the theory of signalling in the presence of noise was already well advanced at the outbreak of the Second World War. Radar, however, presenting the signal-to-noise problem in an extreme form, served as the spur for a spectacular advance in the theory of signalling in the presence of noise, and the statistical theory of communication, evolved by Shannon on the basis of the fundamental quantitative concepts postulated by Hartley some twenty years earlier, was disclosed in a series of publications in the years immediately following the War. This new quantitative theory of information now constitutes an essential background to the theory of modulation in communication systems.

Dr. H. S. Black's book is the first, so far as the present reviewer is aware, to present a comprehensive treatment of modulation based on the concepts and quantitative results of information theory. The first eight of the twenty chapters of the book treat the general considerations underlying systems for the communication of information. After a brief but most informative review of the historical background, consideration is given to the purposes served by modulation and to the kinds of modulation which are employed. One full chapter is directed to the sampling principle and another to quantization, code transmission and multiplexing. In these chapters important basic concepts—for example, the requirement to sample at a rate slightly greater than twice the highest significant signal frequency, and the possibility of the regeneration with complete fidelity of a quantized signal provided the peak interference is less than half a quantum step—are developed with great clarity.

In a chapter entitled "Efficient Systems of Communication" are treated Shannon's central theorem of information theory and the law governing the exchange of band-width for signal power. The concept of the quantitative measure of information is developed, the term entropy is introduced and consideration is given to the efficient encoding of English text. The chapter closes with an interesting comparison of the possible performance of existing systems with the unsurpassable transmission-rate determined by Shannon's central theorem. The next two chapters deal with speed of signalling, channel capacity and the possibility of reducing signal power by the use of redundant codes.

These fundamental considerations occupy more than one-third of the text of the book. Twelve chapters follow in which the various forms of modulation receive detailed treatment. Amplitude and frequency modulation are followed by pulse modulation, there being separate chapters on pulse

amplitude, pulse duration and pulse position modulation, and finally there are two chapters on pulse code modulation systems. The treatment is clear, and simplifications and assumptions are stated with exceptional care. It is the chapters on pulse code modulation which form the most interesting single section of the book, for these furnish an outline of the principles of a system which must be expected to have a profound effect on the future development of long-distance communication. In addition to explaining the principles of multi-channel pulse code modulation, a description is given of a twelve-channel system which employs electron-beam coders and decoders. The final chapter of the book, Chapter 20, deals with the problem of 'distributed' channels, that is to say, systems in which a multiplicity of transmitters has access by a common transmitting medium to any of a similarly numerous group of receivers. The special problems associated with this type of transmission are illustrated by reference to a mobile system.

This book gives a comprehensive treatment of the whole problem of modulation in communication systems, and the treatment is based on the fundamental concepts of information theory. The standard of mathematics required is well within the scope of a university undergraduate course in physics or engineering. It is an especial merit of the work that the subject has been treated on a very general basis, and at the same time investigated in detail in its various branches, without recourse to mathematical methods of a standard beyond that of undergraduate courses. The very success of the treatment evokes the question as to whether it would not have been possible to give an outline of the derivation of Shannon's central formula in the theory of information. This volume is a worthy addition to the series of distinguished text-books which are associated with the Bell Laboratories. JAMES GREIG

PLASTIC DEFORMATION OF CRYSTALS

Dislocations and Plastic Flow in Crystals

By Prof. A. H. Cottrell. (International Series of Monographs on Physics.) Pp. x+223+8 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1953.) 25*s*. net.

PROF. A. H. COTTRELL'S book is an admirable account of the theory of dislocations as applied to the plastic deformation of crystals, and is a valuable starting-point for students of this subject. It is written in an easy and attractive style, with the mathematical treatments outlined but not given in detail; and if there is occasionally a tendency to treat as fact things which have been assumed, or are suggested by somewhat imperfect experiments, this is generally done for the purpose of simple exposition, and the reader need not be misled.

The book begins with an account of the deformation of crystals by slip, and the way in which it is described in terms of the movement of edge and screw dislocations. It then deals with the theory of dislocations in a perfectly elastic isotropic and structureless medium, from which are derived the equations governing the stress field of a dislocation, its strain energy, and the forces between dislocations. The periodic structure of the crystal is next introduced, leading to a discussion of the forms taken by dislocations in crystals, the forces necessary to move them, and the special forms of dislocation that may exist in face-centred cubic, body-centred cubic and hexagonal crystals. Growth spirals in crystals, the Frank–Read source, and the grain boundary, considered as an assemblage of dislocations, are dealt with in this chapter. This chapter and the preceding one are the most permanently valuable part of the book, and will frequently be referred to.

On proceeding to the explanation of the observed behaviour of actual crystals, the book tends inevitably to include a number of speculations, some of which may prove to be short-lived. The number and distribution of dislocations in unworked crystals are considered, with results that direct attention to the uncertainty of present knowledge of these basic facts. The piling of dislocations behind an obstacle, the grain boundary as an obstacle to moving dislocations, the action of dissolved atoms and precipitated particles, and the explanation of the sharp yield-point in some metals in terms of the influence of atmospheres of solute atoms around dislocations are described; but it becomes clear that the mathematical development of the theory has run far ahead of knowledge of the values of the terms appearing in the equations.

In the final chapter, which deals with work-hardening, annealing and creep, great stress is placed on the phenomenon of easy glide. This prepares the way for the author's view that work-hardening is primarily due to the mutual interference of dislocations moving in intersecting planes. This view is plausibly and effectively argued, without neglecting other views that have been expressed. The phenomena of recovery, polygonization and recrystallization prove to be too complex to be more than briefly described, and in selecting for discussion mainly those investigations in which quantitative treatments of the processes have been attempted, the author has produced a picture that appears rather strange to the practical metallurgist. The treatment of creep, on the other hand, is very acceptable, for while it presents a picture of the right general kind, it avoids the temptation to set up a master equation from which all things can be deduced, and keeps a proper balance between the deformation of the crystal and that of the grain boundary. Possibly too much importance is given to exhaustion theories of creep, and the reader is allowed to escape with the impression that, but for the presence of regions of exceptionally easy slip, materials would creep at a uniform rate, which is almost certainly not the case.

Dislocation theory moves so fast that, in spite of efforts to incorporate the results of new investigations up to the time of writing, some things are missing that would have to be included if the book were re-written to-day. Vacancies are mentioned; but little indication is given of the importance they have assumed, rightly or wrongly, in all recent discussions of processes in crystals, and no attention is given to the influence of vacancies formed during plastic deformation on the speed of diffusion processes, and their consequent influence on many of the phenomena discussed in the book. Nevertheless, all workers in solid-state physics will find Prof. Cottrell's work an invaluable guide, fair in its treatment of alternative points of view, stimulating and informative, but not to be regarded as final. Rather it will raise innumerable questions and suggest new investigations to improve the understanding of the strange behaviour of crystals. N. P. ALLEN

A Simple Guide to Modern Valency Theory

By G. I. Brown. Pp. ix+174. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1953.) 12*s*. 6*d*. net.

THE author of this book, a master at Eton College, in framing this concise account of modern ideas on valency acknowledges his debt to the writings of Sidgwick and Linus Pauling. His early chapters contain a good account of the history of valency and of its classical conception. Then follow chapters severally dealing with the covalent, electrovalent and dative bonds and with experimental methods of investigating these linkages. In these chapters Mr. Brown explains clearly and adequately the modern ideas more fully than in the ordinary advanced text-book of chemistry.

Dr. L. E. Sutton, himself a well-known worker in this field, says in the foreword: "present day valency theories concern a very wide range of phenomena . . . [and] cover the whole discussion of potential energy and configuration for atomic, molecular, and intermolecular systems". This conception of the place of valency accounts for chapters on internal dimensions of crystals and molecules; simple examples of resonating molecules; hydrogen and the hydrogen bond; and molecular orbitals. These chapters are well written, and the new terms and ideas are carefully explained by a writer who obviously has a grip of his subject. Nevertheless, I believe that more applications of the new knowledge would improve the book. The theory of molecular orbitals has been used advantageously in promoting an understanding of bonding in organic molecules. The author devotes a whole chapter to this theory, but uses it only to explain why oxygen is paramagnetic. Again, the preface states that the book is intended for sixth-form pupils and for older chemists interested in modern developments. Teachers among these 'older chemists' will be disappointed to find that the author touches but lightly on the time-honoured valency difficulties connected with nitric oxide, carbon monoxide and hydrogen peroxide; also, they will find no answer to the alert sixth-former who asks why does the atom of copper procure valency electrons from the penultimate shell? Still, this is a minor criticism; the author has written a good concise account of modern valency. G. FOWLES

Introduction to Tensors, Spinors, and Relativistic Wave-equations

(Relation Structure.) By Prof. E. M. Corson. Pp. xiii+221. (London and Glasgow: Blackie and Son, Ltd., 1953.) 55*s*. net.

QUANTUM theory of fields has developed along two main lines: one concerning itself with the mathematical basis of the subject; the other, more particularly with the relation of its predictions to experiment. In this volume, Prof. E. M. Corson addresses himself to a unified survey of the first development.

The book starts with a review of tensor and spinor analysis. The canonical formalism and the conservation laws of field theory are considered next, followed by a chapter on relativistic wave equations. The climax of the theoretical development comes with the fifth chapter, where the basis of the theory is sought in abstract algebra and group theory. In the author's words, "here the physicist may find the answers as to how and why a particular covariant formalism is suitable for the description of particles of given spin, and how and why the so-called field aspect of given genus of particles is related to the so-called particle aspect".

The book is by no means easy to read, for considerable familiarity with the concepts of modern algebra is assumed. But to read through with Prof. Corson is an adventure of discovery—a discovery of some of the profoundest ideas in theoretical physics, presented with rare understanding and logical clarity. There is no mention of developments after 1947—possibly, with a gain in the permanent value of the book.

ABDUS SALAM

The Chemical Structure of Proteins

Edited by G. E. W. Wolstenholme and Margaret P. Cameron. (A Ciba Foundation Symposium.) Pp. xii+222+6 plates. (London: J. and A. Churchill, Ltd., 1953.) 25*s*. net.

THIS is a record of a Ciba Foundation Symposium held in London in December 1952. It contains about seventeen papers by recognized authorities and verbatim reports of very frank and illuminating discussions on them. The volume thus contains much interesting reading for all who are interested in protein structure. One might, however, be tempted to question whether publication of these symposia, however interesting they may have been, is in every case necessary. For topics which are not frequently reviewed there is much to be said for publication; but in a much-cultivated field like the structure of proteins, in which three symposia were held within a short period, to a considerable extent with the same participants, which have all been published, there is a good deal of overlapping.

One can sympathize with the desire of the organizers and participants of such conferences to see their news and views dispersed as widely as possible; and readers who have time will undoubtedly find much that is of great interest. But the burden of coping with all such reports is becoming very great, and organizers might try to ensure that the collection they offer will be to a reasonable extent unique.

J. B.

Weed Control in Farm and Garden

By Stephen J. Willis. (Agricultural and Horticultural Students Series.) Pp. 184+6 plates. (London: Vinton and Company, Ltd., 1954.) 8*s*. 6*d*. net.

IT is several years since the appearance of any British book which deals with all aspects of weed control, so that this small volume will be welcomed not only by the students to whom it is primarily addressed but also by many farmers and growers. Although the emphasis is essentially practical, sufficient discussion of basic principles is included to permit intelligent application of control methods, and the result is a well-balanced account of modern techniques.

The first four chapters are concerned with the biology of weeds and the role of hygiene and cultural practice in their prevention. In the main body of the text available chemicals are described, weed responses tabulated and recommendations given for treatment of the various agricultural and horticultural crops. Spraying and dusting machinery is briefly discussed, and special methods for the control of certain perennial weeds and cryptogams outlined. Common and scientific names of weed species and formulæ of herbicides are listed in appendixes, while technical terms are explained as they occur. There is a good index, and the price seems very reasonable.

CLOUD CHAMBER AND ASSOCIATED TECHNIQUES

DURING the past few years there have been several important developments in techniques for the study of the paths of ionizing particles in gases and liquids. The diffusion chamber has now become almost a standard instrument for use with large accelerators, while the Glaser bubble chamber is exciting ever wider interest. The use of large numbers of metal plates in the Wilson chamber has greatly increased its usefulness in many applications, and an increased effort has gone into the operation of Wilson chambers under conditions of high gas pressure. Some of these techniques have been developed specifically for use in cosmic ray applications, while others have been used almost exclusively in association with high-energy particle accelerators. With the commencement of the operation of several such accelerators in Great Britain and the planning of larger ones, the time appeared ripe for an assessment of the relative merits of these various types of particle track detection and of their respective fields of applicability.

In order to discuss these questions, a conference on "Recent Developments in Cloud Chamber and Associated Techniques" was held in the Physics Department at University College, London, during March 24–26. Prof. H. S. W. Massey, opening the conference, outlined the considerations that had led to the decision to convene it in association with the Physical Society. A message of good wishes to the conference from Prof. C. T. R. Wilson, now living in retirement near Edinburgh, was heard with enthusiasm, and it was agreed unanimously to convey to Prof. Wilson the good wishes and respect of those present. Prof. P. M. S. Blackett, taking the chair for the first session, said that in planning a research programme one has to try to envisage the probable scope of research in five or ten years time. Conferences of this kind bring out the direction of development of technique and enable one to decide where the major effort can most fruitfully be placed.

Dr. M. Snowdon (Atomic Energy Research Establishment, Harwell) reviewed the development of the diffusion chamber from the early researches of Langsdorf and Cowan to the more recent work of Shutt, and then went on to describe in some detail the 16-in. diameter diffusion chamber that has now been operated for some time in conjunction with the 150-MeV. synchro-cyclotron at Harwell. In a most illuminating paper on the theory of operation of the chamber, Dr. A. Gigli (Genoa) discussed the factors determining the shape of the sensitive layer and the extent of the insensitive zone near the walls of the chamber. Experience with diffusion chambers in conjunction with the high-energy accelerators now operating in Great Britain was then described by workers from Liverpool (Dr. W. H. Evans, Miss M. H. Alston), Birmingham (Dr. L. Riddiford) and Glasgow (Dr. J. R. Atkinson).

From these and subsequent contributions it was clear that the main advantages of diffusion chambers are their continuous sensitivity and simplicity of construction. The recovery time after the passage of about 100 particles or fewer is of the order of 30 sec., while, even when the full beam of the Liverpool synchro-cyclotron (10^{10} particles) is passed through, the recovery time is only 3 min. The rapid recycling of the diffusion chamber makes it a very suitable tool for operation with pulsed sources of fast particles from machines, and they can readily be operated at pressures up to 25 atmospheres in hydrogen or 15 atmospheres in helium. They suffer from a number of disadvantages, however, such as the shallowness of the sensitive layer and the indefiniteness of its extent and shape. These severely limit the usefulness of the diffusion chamber in cosmic ray investigations. In addition, the time of drop-growth (0·1-0·2 sec.) is long, so that track distortion may be serious, a point which emerged from measurements described by Dr. N. Cusack (Birkbeck College, London) in which two photographs of diffusion chamber tracks were taken separated in time by 0·3 sec.

The second session opened with a review of the technique of the multi-plate chamber by Prof. C. Peyrou (Berne). Apart from the obvious advantage of giving a high yield of particles that stop in the chamber, the plates make possible certain technical improvements in chamber operation. Large clearing fields can be employed between the plates, and this facilitates the use of very deep chambers, while the recovery time is short. With such deep chambers, however, particular attention has to be paid to the damping of the motion of the piston in order to avoid non-uniform expansion throughout the chamber. Distortion is also particularly liable to occur near the plates. Questions of range and scattering in the plates of a multi-plate chamber were described by Drs. F. Muller (École Polytechnique, Paris) and A. W. Wolfendale (Manchester), respectively, while Dr. B. Gregory (École Polytechnique, Paris), in describing the operation of a momentum-measuring chamber (with magnetic field) in association with a multi-plate chamber, stressed the supreme importance of temperature control for accurate work. With temperature control to the nearest 0·1 deg. C. a maximum detectable momentum of 16 GeV./c is attainable.

The conference then passed to the consideration of recent techniques for the control of cloud chambers using scintillation and Čerenkov counters. Dr. B. D. Hyams (Manchester) considered that scintillation counters have no particular advantage over gas proportional counters in fast-particle selection systems; but their use in conjunction with Čerenkov counters permits the selection of slower particles in a definite velocity-range, and an account of experience in this field was given by Dr. D. M. Binnie (Manchester).

In the third session of the conference, experience gained in the operation of a high-pressure cloud chamber filled with argon at a pressure in the neighbourhood of a hundred atmospheres was described by members of the joint cosmic-ray group from University College, London, and from the University of

Edinburgh (see also *Nature* of March 12, page 445). Dr. G. R. Evans (Edinburgh) reviewed the progress made in the operation of high-pressure cloud chambers since his first experience of the technique some sixteen years ago. One of the main difficulties associated with the operation of these chambers is the onset of non-uniform vapour condensation after a few expansions, arising from the establishment of a temperature gradient in the gas which hinders the re-circulation of alcohol vapour to the top of the chamber. Dr. N. Morris (London) described a study of these temperature gradients, while Mr. H. S. Tomlinson (London) discussed the design of 'overcompression' systems for a high-pressure cloud chamber employing a hydraulic control system. Problems associated with the identification and measurement of tracks in high-pressure cloud chambers were discussed by Dr. E. H. S. Burhop and Mr. F. R. Stannard (London) and by Mr. E. J. Williams (Edinburgh), an investigation of distortion in such chambers was described by Mr. P. Baxter (London), and experience gained in their operation (with deuterium filling) in conjunction with the proton beam of the Harwell cyclotron was reported by Dr. T. C. Griffith (London).

The high-pressure cloud chamber possesses the advantage of a great increase in the rate of gas interactions over the conventional Wilson chamber operated at atmospheric pressure. Its sensitive time is long (of the order of 1 sec.); it can operate at pressures much higher than the diffusion chamber, and measurement of multiple scattering and width facilitate particle identification. However, its usefulness in high-altitude cosmic-ray investigation, and particularly in association with high-energy accelerators, depends on the success achieved in reducing the present recycling time of 10–15 min. by means of overcompression or fast recompression.

A return to the discussion of the applicability of overcompression and fast recompression techniques was made in the fourth session, when Drs. N. C. Barford (Imperial College of Science and Technology, London), J. Walker (Birmingham) and J. R. Atkinson (Glasgow) described their experience in the application of the technique to chambers operating near atmospheric pressure. Although it appears that with this technique it is not possible to accomplish the ideal aim of re-evaporating drops before they have had time to fall far after an expansion, it does seem practicable to reduce the recycling time by a factor of 5–10.

The greater part of this session was devoted to a discussion of the bubble chamber. Dr. C. Dodd (University College, London) reviewed the development of this new technique. A considerable amount of experience is now available on the use of pentane and liquid hydrogen in such chambers. Apart from the high density of the operating fluid—an advantage which it shares with the high-pressure cloud chamber—the bubble chamber is characterized by a rapid rate of bubble growth, so that distortion due to liquid motions is likely to be small. Another advantage is the absence of background due to old tracks. Bubble chambers have come to be classified into two types: the smaller 'clean' chamber contains no plane surfaces, no boiling occurs until an ionizing particle passes through, and the rate of bubble growth is very rapid; large 'dirty' chambers, with plane metal walls and glass windows for illumination and photography, which boil continuously at corners and at metal–glass boundaries, but the rate of bubble growth may be up to a thousand times slower than in a clean chamber. As a result, the central portion of a 'dirty' chamber remains in a sensitive condition for a few milliseconds after removal of the pressure, and this means that quite large bubble chambers of this type can be operated effectively in conjunction with particle accelerators; such a chamber operating with 15 gallons of liquid hydrogen is being constructed at the University of California, Berkeley. Great interest was aroused by the reading of a paper submitted by D. Parmentier and A. J. Schwemin, of Berkeley, which arrived two days before the conference and showed pictures of meson tracks from the Berkeley bevatron taken with a liquid-hydrogen bubble chamber.

Prof. G. Martelli (Pisa) discussed some theoretical aspects of the operation of the bubble chamber, while the construction of a bubble chamber designed to test the applicability of the method to cosmic ray investigations was described by Prof. P. Bassi (Padua). For cosmic-ray applications the bubble chamber faces severe limitations, because counter control cannot be used to put the chamber into a sensitive condition. But if the sensitive time could be extended so that the chamber remained sensitive for a large fraction of the total time, it would need to be considered seriously for cosmic ray work. There seems some prospect of achieving this by operating at increased temperature and by care in selection of the material of the metal walls of the chamber. The bubble chamber technique shows great promise; but the apparatus for large-volume chambers tends to become very complex, and little work has so far been done on the identification and measurement of bubble-chamber tracks.

The fifth session dealt with the interpretation of cloud-chamber photographs. After a review of the problems by Dr. A. L. Hodson (Leeds), important new advances in the measurement of specific ionization were described by Dr. C. A. Uttley (Imperial College of Science and Technology, London) using drop counting, and by Dr. I. Butterworth (Manchester) using a photometric method. Mr. A. L. Rodgers (Manchester) described momentum measurements with shallow Wilson chambers in conjunction with a magnetic spectrometer capable of measuring momenta up to 10^{12} eV./c, while Dr. R. R. Rau (Princeton) described the momentum cloud chamber and reprojection system used by the Princeton group. Interesting examples of the use of internal counters to detect positron–electron pairs in a Wilson chamber were described by Dr. W. T. Davies (Oxford), and a high-frequency method of the time-marking of particle tracks was suggested by Dr. D. Gabor (Imperial College of Science and Technology, London). Suggestions of other particle track techniques were made by Mr. A. R. Bevan (University College, London) (employing high-frequency discharges localized along the tracks of ionizing particles) and in a contributed paper by Dr. C. E. Nielsen (Ohio) on a vapour cloud chamber.

When this conference was planned it was thought it would appeal to only a small group of specialists. As it turned out, the attendance exceeded one hundred and twenty. The animated discussion that followed each session and that continued in groups long after the sessions had concluded is the best testimony to the need for such a conference, which proved of great value in placing in their correct perspective these various new techniques. E. H. S. Burhop

MOLECULAR STRUCTURE OF DEOXYRIBOSE NUCLEIC ACID AND NUCLEOPROTEIN

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THE molecular structure of deoxyribose nucleic acid and nucleoprotein will probably provide the basis for chemical interpretation of genetical phenomena (cf. refs. 1–3) and of the reproduction of nucleic acids and proteins. It has been shown that deoxyribose nucleic acid has a helical structure[4,5], and Watson and Crick have proposed a structure involving a special type of pairing of nitrogen bases[6,7], and, from the structure, derived a hypothesis concerning the self-duplication of nucleic acid[8]. Information about the structure of deoxyribose nucleoprotein has been scanty (see ref. 9), and it has been suggested that deoxyribose nucleic acid may not be closely combined with protein[10]. This communication describes in a preliminary way X-ray diffraction and molecular model-building studies which show that a helical structure of deoxyribose nucleic acid involving the base-pairing of Watson and Crick can be used to explain very satisfactorily a large amount of observed data. It is also shown that deoxyribose nucleoprotein is definitely a compound of protein with nucleic acid. The nucleoprotein structure is derived as a step towards finding the molecular structure of chromosomes and does not at this stage necessarily suggest any ideas about biological replication, etc.

Structure of Deoxyribose Nucleic Acid

The helical nucleic acid molecule has, in the solid state, two main configurations[12]: the very compressed and highly crystalline *A* structure, and the slightly more extended helix, the *B* structure, which is often paracrystalline. Here we are concerned only with the *B* structure, which is the form in which the nucleic acid exists when combined with protein.

The approximate diameter and pitch of the nucleic acid helix were derived directly from the X-ray diffraction pattern[4,5], and it was clear that two or more polynucleotide chains were twisted around one another in the nucleic acid molecule[4,5] and that the chains were bound together by hydrogen bonds between bases[5,13]. Watson and Crick[6] provided a special scheme for this bonding and built a molecular model.

The exact configuration proposed by them was not correct[11,14]. This was shown by lack of agreement between the Fourier transform of their model and the observed X-ray diffraction pattern. In particular, the general diameter of their model was rather too large. It remained to be shown that it was possible to build a model which contained the Watson and Crick hydrogen bonding and which gave the required Fourier transform. The general nature of such a modified *B* structure has already been described briefly by some of us[11]. It has also been shown[4] that the shape of the pair of nucleotides must

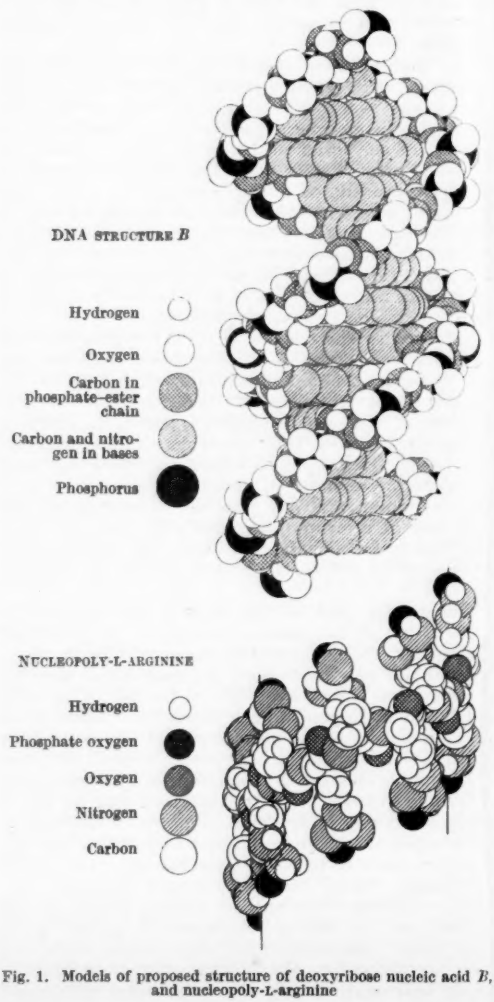

Fig. 1. Models of proposed structure of deoxyribose nucleic acid *B*, and nucleopoly-L-arginine

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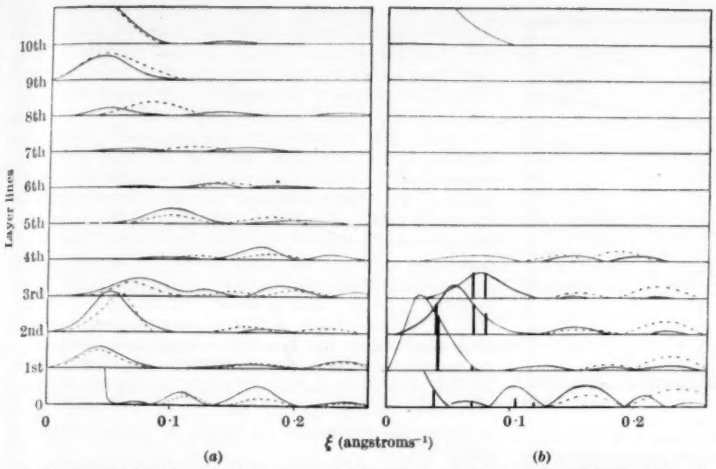

Fig. 2. Calculated and observed transforms of deoxyribose nucleic acid and nucleoprotamine: (*a*) The dotted curve shows the plot in reciprocal space of the observed intensities of X-ray diffraction from nucleic acid *B*. The continuous curve is the square of the Fourier transform of the proposed structure. (*b*) The dotted curve and vertical lines show the observed X-ray diffraction from nucleoprotamine. The continuous curve is the square of the transform of the proposed structure. (The intensity scale of the central maximum is on a reduced scale of one-tenth that of the remainder of the diagram.)

take roughly the form of a rod passing approximately through the helix axis and at right-angles to it. This is so if the pair of bases in the Watson and Crick model is moved towards the helix axis. This movement also has the desired effect of reducing the general diameter of the molecule. Furthermore, the distribution of electron density in the molecule must not alter suddenly at a given radius of the helix, but must decrease gradually near the outside of the molecule, thus reducing the magnitude of secondary diffraction maxima on the equator of the diffraction pattern. (In the *A* structure much of the electron density is concentrated at one radius[11].) This may be achieved if the sugar ring in each nucleotide is placed so that its plane is inclined as much as possible to the helix axis.

If such molecular models are built on the assumption[7] that the sugar ring is non-planar as in ribose, many interatomic distances are found always to be much smaller (for example, C—O 2·6 A.; C—P 2·9 A.) than the usual Van der Waals values. However, it appears very reasonable to expect that the sugar ring may have a slightly different configuration either intrinsically or as a result of distortion. The polynucleotide chain will be compressed by large attractive forces between the phosphate ions and the hydrated sodium ions which are surrounded by oriented water of low dielectric constant. These forces may easily distort bond angles by a few degrees and thus may alter considerably the non-planarity of the sugar ring. It has been found that small interatomic distances can be avoided if the sugar ring is approximately planar (the only short contact being a C—O distance of 2·9 A.). It may be expected that the interatomic distances in such a compressed chain molecule will tend to be small. The general appearance of the molecule is shown in Fig. 1. The model cannot be precise, because many bond angles and lengths are not known accurately; but the transform of the model has a close correspondence with the observed X-ray diffraction (Fig. 2).

To calculate the transform, assumptions must be made about the position of the sodium ions and of the water in the structure. The amplitude of the X-rays scattered by the sodium ions is about one-sixth that of the nucleic acid immersed in water. The *B* configuration of nucleic acid is well defined when the relative humidity of the surrounding atmosphere ranges from 85 to 95 per cent or more, and nucleoprotein gives a good X-ray pattern at 95–100 per cent humidity. As the humidity is high, it is reasonable to suppose that all available space around the molecules of nucleic acid and nucleoprotamine is filled by water. The sodium ions are probably each surrounded by about six water molecules, and the strong attraction between the sodium ions and the phosphate group will keep the Na^+—O^- distance ~ 5 A. Mutual repulsion of the sodium ions will tend to distribute the sodium ions in the direction of the helix axis, alternately above and below the phosphate chain.

Evidence for Chemical Combination of Protein and Deoxyribose Nucleic Acid

In synthetic deoxyribose nucleoprotein, made by combining nucleic acid and protamine, the ratio between the numbers of basic amino-acids and phosphate groups may be varied (see refs. 15, 16); but in sperm heads the ratio is always close to unity[17], and this stoichiometric relation has been taken as evidence for chemical combination.

Deoxyribose nucleic acid is normally prepared as the sodium salt. If protein in nucleoprotein is combined with the nucleic acid, the extent of the binding may be determined by the proportion of sodium ions displaced from the nucleic acid. Flame photometry (kindly done by Mr. A. J. Rose and Mr. J. F. Becker, of the Courtauld Institute, Middlesex Hospital, London) shows that there is one sodium ion per phosphate group in our nucleic acid specimens (see also ref. 18), and that in intact sperm heads of trout, and in nucleoprotein extracted from the sperm of trout and herring, there is about one-tenth or less of this amount of total sodium and potassium.

Furthermore, it has been suggested[19] that, if protein is arranged around each nucleic acid helical unit, then the sideways separation of the nucleic acid molecules, obtained by X-ray diffraction, will be greater in nucleoprotein than in nucleic acid. However, no valid evidence of this kind has been produced, because the large proportion of water in the structure has not been taken into account. Fig. 3 shows how the relevant X-ray spacings vary with relative humidity. At low water contents the molecules are closely shrunk together and are farther apart in nucleoprotein than in nucleic acid, as one would expect. Owing apparently to the hydration of the sodium ions, the nucleic acid swells markedly with

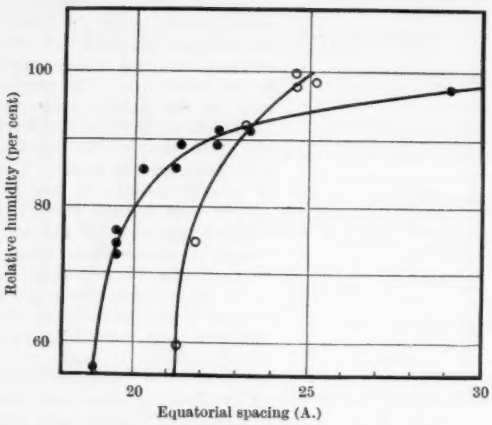

Fig. 3. Swelling of deoxyribose nucleic acid (sodium salt) and deoxyribose nucleoprotamine. Curves show the variation of equatorial spacing with humidity
●, Nucleic acid; ○, nucleoprotamine

increasing relative humidity of the surrounding atmosphere and finally dissolves. The nucleoprotein swells much less and is insoluble in water. At about 92 per cent relative humidity, the X-ray spacings are equal for nucleoprotein and nucleic acid, and the water contents per 100 parts by weight of nucleic acid are respectively 52 and 95. This difference of water content is about that which one would expect if the protein were between the nucleic acid helical units and presumably bound to them.

The general appearance of the X-ray diffraction pictures of deoxyribose nucleic acid and nucleoprotamine is very similar[4]; but a difference of molecular structure is definitely indicated by the fact that the first layer line on the nucleoprotein picture is appreciably stronger than that for nucleic acid. Again, deoxyribose nucleoprotein always occurs in a hexagonal crystalline form, but nucleic acid occurs either in a different hexagonal form or partially paracrystalline. This difference of lattices, resulting from a different packing together of molecules, indicates a difference of shape of nucleoprotein and nucleic acid molecules.

Molecular Models of Nucleoprotamine

A protamine molecule is believed to consist of one polypeptide chain, with about two-thirds of the amino-acid residues arginine[17], in which groups of four consecutive arginines frequently occur. The only way in which we have been able to arrange polyarginine with respect to deoxyribose nucleic acid so that the basic end-groups of the side chains are close to the phosphate groups is to wrap the fully extended polypeptide chain helically around[8] the nucleic acid helix. (No water was introduced between the phosphate and guanidinium groups.) The repeat distance along the fully-extended polypeptide chain is equal to the separation of the nucleotides along the polynucleotide chain, and the distance between the ends of the successive side-chains pointing in opposite directions is equal to the separation, in the helix axis direction, of the two phosphate helices on the nucleic acid molecule (see Fig. 1). In this way the polyarginine part of protamine may be combined with deoxyribose nucleic acid without distorting the nucleic acid molecule. Such a nucleopoly-L-arginine structure gives the observed increase of intensity of the first layer line of the nucleoprotamine X-ray picture relative to that for deoxyribose nucleic acid (Fig. 2). Studies of protamine have suggested[16] that the non-basic residues may be distributed in all of the molecular components and, as each phosphate appears to be combined with an arginine in nucleoprotamine, it seems desirable to be able to accommodate non-basic residues in the nucleoprotamine structure while permitting all arginines to combine as above with phosphate groups. This will be so if the non-basic groups are introduced as loops in the polypeptide chain between two arginines. It is not possible to form such a loop with a single residue; but, if two non-basic residues occur together, a suitable loop may be formed. Sequence analysis of protamine[17,20] shows that non-basic residues do occur almost entirely in pairs, and hence it may be supposed that this rather special feature of the amino-acid sequence is explicable in terms of nucleoprotamine structure.

Density and Water Content Measurements

The correspondence between the observed X-ray diffraction patterns and the intensities calculated from the proposed structures is good (Fig. 2), and the ability to account for both the nucleic acid and nucleoprotein data makes the proposed structure especially convincing. Density and water-content measurements, however, do not agree well with the proposed structures; but such disagreement is not uncommon when the structure of fibres of biological material is considered. The densities of nucleic acid and nucleoprotein at 92 per cent relative humidity are between 1·34 and 1·39 (gm./c.c.). If the molecules are considered as immersed in water of density 1 (gm./c.c.), the theoretical densities are 1·26 and 1·33 (gm./c.c.), and the water contents per 100 parts by weight of nucleic acid are 147 and 85, respectively.

The observed values agree better with a three-chain than a two-chain structure; but in the less hydrated nucleic acid structure *A* (which must be of the same basic form) the corresponding data agree well with a two-chain structure[11,14]. An obvious explanation is that nucleic acid fibres contain a large fraction of imperfectly crystalline material and, when in the *B*-form, the non-crystalline material has lower hydration than the crystalline. This hypothesis is supported by measurements of ultra-violet dichroism, which give values much lower than would be expected if the fibres consisted largely of the proposed structures.

X-Ray Diffraction Observations

The *B*-structure of nucleic acid often crystallizes with a hexagonal lattice which can swell and shrink in directions at right-angles to the *c*-axis ($a = 46$ A., $c = 34{\cdot}6$ A. at 92 per cent relative humidity, and $a = 39$ A., $c = 34{\cdot}6$ A. at 75 per cent relative humidity); the lattice is never very perfect, but as many as sixteen reflexions have been indexed (Fig. 4*a*). Some specimens show continuous streaks along the layer lines superimposed on the crystalline reflexions, thus indicating that some of the repeat units are arranged at random in the *c*-direction; that is, some of the material is paracrystalline. One specimen (Fig. 4*b*) gave continuous streaks and no lattice reflexions on the first and third layer lines,

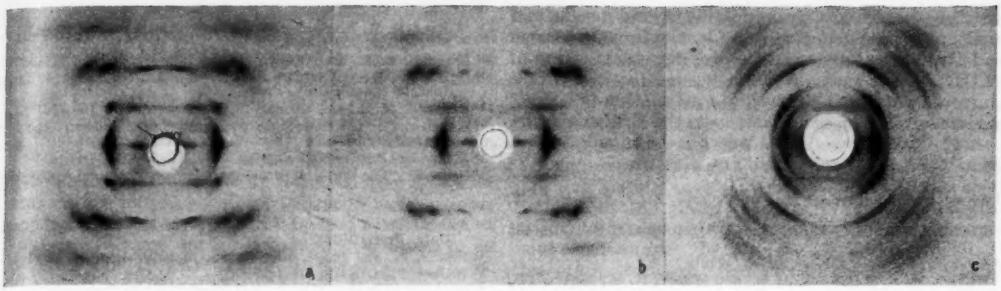

Fig. 4. Central regions of X-ray fibre diagrams of:

(a) Deoxyribose nucleic acid at 92 per cent relative humidity, showing spots on all layer lines. Crystalline *B* structure. (Nucleic acid from Dr. N. S. Simmons.)

(b) Deoxyribose nucleic acid at 92 per cent relative humidity, showing spots on even layer lines only.

(c) Nucleoprotamine (*Sepia* sperm heads) at 98 per cent relative humidity.

and lattice reflexions and no streak on the second and zero layer lines. This means that repeat units are arranged with relative displacement in the *c*-direction of $\frac{1}{2}c$ up and down at random. The layer-line streaks are especially useful in providing the whole structure factor along a layer line. Several possible reflexions are noticeable by their absence in the *B*-crystalline X-ray picture, and this may be accounted for by considering the crystal as consisting of nucleic acid molecules packed hexagonally, in projection on a plane perpendicular to the fibre axis, but with adjacent molecules displaced up and down one-sixth and one-third of the helix period relative to one another. If this arrangement is regular, the hexagonal crystalline structure results, the repeat unit involving three nucleic acid molecules; and if irregular, the various paracrystalline structures are produced.

The lattice of the nucleoprotamine (sperm heads from a variety of species and extracted material) is always hexagonal ($a = 28{\cdot}7$ A., $c = 34{\cdot}4$ A. at 98 per cent relative humidity) and fifteen reflexions have been indexed (Fig. 4*c*). The repeat unit involves one deoxyribose nucleic acid molecule, and packing of the molecules suggests that the molecule as a whole resembles a single-fold helix, probably as a result of the single polypeptide helix existing on the outside of the two-fold nucleic acid helix. The X-ray photographs were measured using a recording densitometer[21], and the structure factor deduced.

Calculation of the Fourier Transforms of the Molecular Models

The Fourier transforms were calculated using tables of Bessel functions[4,22] and by drawing phase-amplitude diagrams. The calculations were checked by densitometer measurement on a photograph obtained on a Lipson optical diffraction apparatus using a mask with holes produced by photographic etching[23]. The weighting of the atoms, in terms of amplitude of X-rays scattered, was found as follows. That part of the diffraction which takes the form of a system of Bessel functions radiating from the centre of the pattern is produced by the gross helical form of the molecule immersed in water, irrespective of atomic detail; hence the electron density of water (of unit density) was subtracted from the average electron density of each atom. The outer part of the diffraction pattern, consisting of a system of Bessel functions radiating from origins displaced from the centre of the pattern[4,22], arises from periodicities in the electron density inside the polynucleotide helix. As water does not penetrate between the atoms in each helix, no subtraction of electron density of water was made, and relative weighting of the scattering from atoms was different from that above.

Possible Chemical Activity and Biological Functioning of the Molecule

X-ray diffraction shows that deoxyribose nucleic acid *in vivo* has the same molecular configuration when bound to protamine (or possibly histone) in sperm heads, or when in T_2 and T_4 bacteriophage. It remains to be shown, however, that this structure also exists in interphase cell nuclei or in functioning and duplicating chromosomes.

In any event, it may be useful to consider some characteristics of the proposed nucleic acid structure which may have a bearing on its chemical and biological activity. First, the regular spacing of phosphate groups is necessary for effective combination with basic polypeptides; if the molecule is much distorted, such efficient combination cannot take place. Second, the nitrogen bases and sugar rings present a large external surface on the molecule so that, if other molecules lie on this surface, important Van der Waals attraction may take place. For example, basic dyes do not combine with mononucleotides[24] but are bound to nucleic acid. Probably these dyes are bound, not only by ionic linkage to the phosphate groups, but also lie with their planes in close contact with the base-sugar surface of the nucleic acid molecule. Such effects may also be important in protein–nucleic acid interaction. Third, it appears quite feasible for short side-chains to the main polynucleotide chain to occur as branches at triply-esterified phosphate groups and to lie in the grooves of the helix without interfering much with the packing of the deoxyribose nucleic acid molecules. Such side chains could terminate in secondary phosphoryl groups[25]. Fourth, the free amino-groups of guanine[6,26] occur at the bottom of a shallow groove about 8 A. wide and about 6 A. deep and are readily accessible to approaching molecules. The biological specificity of nucleic acid may well depend on the presence of these amino-groups[27] and the secondary phosphoryl groups at the ends of branches.

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NEWS and VIEWS

Royal Society: New Foreign Members

The election of Dr. G. W. Corner, Prof. W. Heisenberg, Prof. Lise Meitner and Prof. Otto Renner to foreign membership of the Royal Society was announced in *Nature* of May 7. The following notes survey very briefly the main fields of their scientific activities.

Dr. G. W. Corner

Dr. G. W. Corner is the director of the Department of Embryology of the Carnegie Institute of Washington. Over a period of forty years his name has been pre-eminent in studies of the anatomy and physiology of mammalian and, in particular, of primate reproduction. His first research was concerned with the structure and function of the corpus luteum of the sow. His next big piece of work, published in 1923, was a report of the experimental analysis of the menstrual cycle of the rhesus monkey. This was the first study of its kind, and it revealed, among other outstanding facts, that the endometrium may break down without ovulation having occurred. A few years later, Corner was responsible, with Willard Allen, for the isolation of the hormone now known as progesterone, and so began a major development in the whole field of endocrinology. More recently, his studies have been concerned with the analysis of the hormonal basis of the uterine cycle in Primates; with the further description of different varieties of corpus luteum; and with studies of early embryos. Dr. Corner is also a well-known student of medical history, and in a series of books has demonstrated that the physiology of reproduction can be expounded in a way which appeals to, and is understandable by, an audience much wider than laboratory scientists. Dr. Corner is vice-president of the U.S. National Academy of Sciences and also of the American Philosophical Society. Before taking up his present appointment in Baltimore he was head of the Department of Anatomy in the Medical School of the University of Rochester. He held the Thomas Vicary Lectureship of the Royal College of Surgeons of London in 1936; and was George Eastman visiting professor in the University of Oxford during 1952–53.

Prof. W. Heisenberg

Prof. W. Heisenberg is perhaps best known for his outstanding work in the development of quantum mechanics. In co-operation with Born and Jordan, he developed the first matrix form of the theory, which was later shown to be equivalent to the wave mechanics of Schrödinger. Then he was prominent in pointing out the restrictions on the simultaneous measurement of position and momentum which quantum mechanics implies, and the well-known 'Uncertainty Principle' is named after him. Another outstanding achievement of this period was his theory of ferromagnetism, which was the first to show how the molecular field which Weiss had introduced to account for this phenomenon could be explained in terms of the concept which we now call the exchange force. Prof. Heisenberg in addition has been a leader in the development of nuclear physics in Germany, and during the War took part in the German atomic energy project. Since the War he has been responsible for much of the reorganization of German science and for the plans for the development of nuclear energy there. In addition, he has continued his fundamental scientific research in many subjects, including cosmic rays, turbulence and superconductivity.

Prof. Lise Meitner

Prof. Lise Meitner is one of the pioneers in the study of radioactivity. Born in Austria in 1878, she took a doctorate at the University of Vienna when women students were considered freaks and subject to all kinds of unpleasantness. Her first publication on a problem in radioactivity dates from 1906, and the next year she went to Berlin and began her collaboration with the chemist, O. Hahn, which was to continue for more than thirty years. She developed the magnetic deflexion of β-rays into an accurate method revealing the presence of sharp energy groups; from such measurements she proved that γ-rays are emitted not before but after radioactive transformation. Among radioactive substances discovered together with Hahn, the mother substance of actinium deserves special mention; they called it protactinium

(not protoactinium as it is often misspelt nowadays). The study of radioactive recoils, of neutron-induced reactions in cloud chambers and of the absorption of γ-rays are a few more topics out of many. Professor in the University of Berlin since 1926 and joint director—with Hahn—of the Kaiser Wilhelm Institut für Chemie in Berlin since 1931, she left Germany in 1938 and has since lived and continued her research in Sweden. Her work with Hahn on the effects of neutrons on uranium came to fruition shortly after she left, in the discovery by Hahn and Strassmann of the formation of much lighter elements such as barium; but it was she (in a paper with O. R. Frisch) who explained the process in terms of Bohr's drop model of the nucleus as nuclear fission.

Prof. Otto Renner

Prof. Otto Renner has been professor of botany first at Jena and, since the War, at Munich. Renner's early work was directed chiefly to plant physiology. Between 1910 and 1915 he was interested especially in the problem of the ascent of sap and contributed a number of observations and theoretical considerations in support of Dixon's cohesion theory. For example, he developed the ingenious method of using fern sporangia for determining the cohesive strength of water. From 1912, however, he turned more and more towards genetic studies on *Oenothera*, for which he is chiefly known. Thirty years ago the importance of Renner's work on *Oenothera* would have seemed to lie in his breeding experiments, which resolved de Vries's mutation theory in terms of orthodox genetics. In the perspective of to-day his work has become much more significant than this. For it now appears that the complex differences in *Oenothera* are something between the gene differences as understood in ordinary Mendelian experiments and the differences existing between natural species. Renner put these differences into relation with the chromosomes on which they were based and also with the cytoplasmic elements with which they interacted. He also put them into relation with their developmental expression in the pollen and in the embryo sac, thus illuminating the general problem of fertility. Finally, others working on Renner's foundations have put them in relation to evolutionary processes. In short, no account of the genetics of higher organisms, whether physiological, cytological or evolutionary, would be satisfactory or convincing to-day which did not pay attention to Renner's work.

Johann Georg Gmelin (1709–55)

The Gmelin family of Tübingen in Germany included several distinguished medical practitioners and scientific workers during the seventeenth and eighteenth centuries. Leopold is remembered for his discovery of potassium ferrocyanide in 1822 and for his "Handbuch der Chemie" (1817–19). His father's cousin, Christian Gottlieb, invented a process for the artificial manufacture of ultramarine in 1828 and was the first to observe the red coloration given to a flame by lithium salts. Johann Georg Gmelin, who died two hundred years ago on May 20, 1755, made his name as a botanist, chemist, pharmacologist and explorer. Son of the apothecary and chemist, Johann Georg Gmelin, he was born in Tübingen on June 12, 1709, and at the early age of fourteen began to study medicine in the local University. In 1725 he publicly defended a dissertation "De glandularum mesentericarum in chylum actione retardativa", and graduated M.D. in 1727. Following in the footsteps of two of his teachers, Johann Duvernoy and Georg Bernhard von Bülfinger, he went to St. Petersburg that same year and obtained a scholarship at the Imperial Academy of Sciences, which had recently been founded by Peter the Great at the instigation of Laurentius Blumentrost the younger, who served as its first president during 1725–33. Gmelin was appointed professor of chemistry and natural history in 1731 and two years later, at the request of the Empress Anna Ivanovna, undertook to explore Siberia in the company of the geographer and astronomer, Delisle de la Croyère, and the historian, Gerhard Friedrich Müller. He returned to St. Petersburg in 1743 and later published his monumental works, "Flora Sibirica" (4 vols., 1747) and "Reisen durch Siberien" (4 vols., 1751). In 1749 he was elected professor of medicine, chemistry and botany at Tübingen, where he died six years later of 'a fever' at the early age of forty-five. The bibliography of his writings in W. M. von Richter's "Geschichte der Medicin in Russland" (3, 219; 1817) includes the dissertations "De rhabarbaro" and "Corticis peruviani in febribus intermittentibus usum".

The Nature Conservancy: New Members

The Nature Conservancy announces that the following have been appointed as members: Sir Basil Neven-Spence, Dr. F. Fraser Darling and Sir Wavell Wakefield. The vacancies have arisen through the death of Sir Edward Keeling and the retirement (on completion of their terms of service) of Sir Norman Kinnear and of Prof. J. R. Matthews, who remains a member of the Scottish Committee and the Scientific Policy Committee, but is succeeded by Sir Basil Neven-Spence as chairman of the Scottish Committee. Dr. C. B. Williams and Major D. C. Bowser have been appointed members of the Conservancy's Scottish Committee in succession to Prof. A. D. Peacock and Dr. D. N. McArthur, who have retired on completion of their terms of service. Mr. C. M. Floyd has been appointed a member of the Committee for England. Dr. V. M. Conway has been appointed director of the Conservancy's Merlewood Research Station at Grange-over-Sands in succession to Dr. K. R. S. Morris, who has resigned.

Royal Aeronautical Society: Awards

The following awards have been made by the Royal Aeronautical Society: *The Society's Gold Medal:* Lord Hives, for his outstanding work in the field of propulsion of aircraft; *The Society's Silver Medals:* Dr. R. A. Frazer, for his outstanding work in aerodynamics over a period of many years, and Dr. A. A. Griffith, for his outstanding research contributions on aircraft engine design; *The Society's Bronze Medal:* Prof. M. J. Lighthill, for his contributions to aeronautical knowledge; *Wakefield Gold Medal:* Mr. J. Taylor, for the design and development of the counting accelerometer; *The British Gold Medal:* Mr. G. H. Dowty, for his outstanding practical achievement in the design and development of aircraft accessory systems; *The British Silver Medal:* Dr. S. G. Hooker, for his practical achievement in the design and development of aero engines; *George Taylor (of Australia) Gold Medal:* Mr. R. C. Morgan, for his paper on "Practical Experience of Airline Engineering"; *Simms Gold Medal:* Dr. D. Williams, for his paper on "Recent Developments in the Structural Approach to Aeroelastic Problems".

Medical Effects of Nuclear Radiation

The Medical Research Council has set up the following committee to prepare a report on the medical aspects of nuclear radiation: Sir Harold Himsworth (*chairman*), secretary of the Medical Research Council; Sir Ernest Rock Carling, consultant adviser, Ministries of Health and Home Office (Civil Defence), and member of the health policy committee of the Atomic Energy Authority; Sir John Cockcroft, director, Atomic Energy Research Establishment; Prof. A. Haddow, director, Chester Beatty Research Institute; Dr. J. F. Loutit, director, Medical Research Council Radiobiological Research Unit; Prof. K. Mather, professor of genetics, University of Birmingham; Prof. W. V. Mayneord, professor of physics applied to medicine, University of London; Prof. P. B. Medawar, professor of zoology and comparative anatomy, University College, London; Prof. J. S. Mitchell, professor of radiotherapeutics, University of Cambridge; Prof. L. S. Penrose, Galton professor of eugenics, University College, London; Sir Edward Salisbury, director, Royal Botanic Gardens; Dr. F. G. Spear, deputy director, Strangeways Research Laboratory, Cambridge; Prof. J. R. Squire, professor of experimental pathology, University of Birmingham; Prof. C. H. Waddington, professor of animal genetics, University of Edinburgh; Sir Lionel Whitby, regius professor of physic, University of Cambridge; Prof. B. W. Windeyer, professor of radiology (therapeutic), University of London.

Anglo-French Atomic Agreement

The United Kingdom Atomic Energy Authority and the French Atomic Energy Commission have recently concluded an agreement for the exchange of unclassified information between the two organizations on a range of subjects. The United Kingdom Atomic Energy Authority will furthermore help the French Atomic Energy Commission by giving advice and by supplying experimental quantities of various materials. The purpose of the agreement is to promote and develop the peaceful uses of atomic energy in the two countries in conformity with the movement for international co-operation in the field of atomic energy on a world-wide scale.

Extraction-Rates of Flour

In a written reply to a question in the House of Commons, the Minister of Agriculture, Fisheries and Food stated that, in conjunction with the Secretary of State for Scotland and the Minister of Health, he is arranging for an independent authoritative review of the scientific and medical evidence now available of the differences in the composition and nutritional value of flour of varying extraction-rates. Lord Adrian, president of the Royal Society, has nominated the following panel to conduct such a review: Sir Henry Cohen, professor of medicine, Liverpool (*chairman*); Prof. L. J. Witts, professor of clinical medicine, Oxford; Prof. J. H. Gaddum, professor of materia medica, Edinburgh; Prof. A. C. Chibnall, formerly professor of biochemistry, Cambridge; Prof. R. A. Morton, professor of biochemistry, Liverpool.

Chemical Engineering in Britain

In his presidential address entitled "Chemical Engineering—the Way Ahead" at the thirty-third annual meeting of the Institution of Chemical Engineers on April 26, Sir Harold Hartley directed attention to the great progress made by chemical engineering since his last address three years ago. Chemical engineering is now generally recognized as a separate branch of technology of the highest importance to industry, and new departments and laboratories have been created in many universities for training students and for research. The Institution has played an important part in these developments, and its activities will be greatly helped by the new headquarters it has acquired through the generosity of its industrial friends.

Chemical engineering is already so wide a subject that it is quite impossible for any one man to master all its ramifications; in spite of this, the tendency is for still wider development, and several growing branches of technology are in need of ever-increasing numbers of specially trained chemical engineers. Sir Harold dealt particularly with three of these branches: the first is 'extractive metallurgy', which is tending to supplant many of the older mechanical processes of ore concentration by chemical treatment, especially in the case of new or comparatively rare metals, and low-grade ores. The second is the so-called 'biochemical engineering', which calls for a special fundamental training in biochemistry, in order to be able to design plant for the extremely complicated processes involved in the production of antibiotics and similar bodies. The third is 'instrumentation and automatic control': many plants of the future will have to be designed for automatic control, which is by no means the same thing as the addition of automatic control to existing plants. At present there is an almost complete lack of information on plant and process characteristics, and a great shortage of chemical engineers with sufficient understanding of the theory of automatic control, so that progress is very difficult. An essential requirement for this progress, which Sir Harold barely mentioned, is to find some means of diverting a proportion of first-class chemical engineers, whether students or those with greater experience, from industry into the teaching profession, which, at present, is pitifully small in numbers. Unless this can be done, and at a very early date, chemical engineering is in danger of resembling a magnificently designed plant which cannot be worked efficiently through lack of operatives.

Third Pan-African Congress on Prehistory, Livingstone

The Third Pan-African Congress on Prehistory will be held in Livingstone, Northern Rhodesia, during July 22–28, during which time the Congress will be in session at the Rhodes–Livingstone Museum. Before the meeting there will be a seven-day excursion to prehistoric sites in Southern Rhodesia, and after July 28 an excursion will be made to sites in Northern Rhodesia and the Katanga Province of the Belgian Congo. In addition to the various sectional meetings, it is proposed to hold special symposia on the following subjects: the Kalahari Sands, their definition, age, distribution and method of formation; the dating of the Australopithecinæ; marine strandlines, their definition, altimetric and faunal correlation (these being reports by the Commission for the Study of Strandlines, set up by the fourth congress of the International Association on Quaternary Research); the early pebble-tool cultures, their definition, dating and distribution; and the importance and the application of the carbon-14 method of dating to African prehistoric cultures. It is also hoped that

the committee on terminology will hold discussions on the following points: whether a true Levalloisian culture exists in Africa or even in Europe; and the application of the terms 'Early', 'Middle' and 'Late', as against 'Paleo-', 'Meso-' and 'Neo', in Africa and to which areas these terms should apply. The official languages of the Congress will be English, French and German. Further information can be obtained from the Organizing Secretary of the Congress at the Rhodes–Livingstone Museum, P.O. Box 124, Livingstone, Northern Rhodesia.

Engineering Aspects of Combustion: Joint Conference in Boston, Mass., and London

A JOINT conference on combustion has been arranged by the American Society of Mechanical Engineers and the Institution of Mechanical Engineers and will be held in Boston, Mass., during June 15–17 and in London during October 25–27. The object of the conference will be two-fold: to link theory and practice in the field of combustion by presenting the results of theoretical work to practical engineers in the United States, Great Britain and other countries; and to provide an opportunity for practical engineers in these countries to meet together to discuss the applications of theory in the fields of boilers, furnaces, internal combustion engines and gas turbines. Forty papers have been prepared, eighteen by members of the American Institution, and these will be read at both the Boston and London meetings; they are divided between the following five sections: general; boilers; industrial furnaces; internal-combustion engines; and gas turbines. Seventeen other institutions and societies in Great Britain are supporting the Institution of Mechanical Engineers, and the various sessions and facilities to purchase the relevant literature are open to members of all these organizations. Further information can be obtained from the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Announcements

THE Otto Schott Commemoration Medal of the Deutsche Glastechnische Gesellschaft has been awarded to Prof. W. E. S. Turner, honorary president of the International Commission on Glass. The Medal is a rare distinction, having been awarded only three times during the past twenty-five years, and Prof. Turner is the first non-German recipient.

THE Challenger Society is prepared to consider applications for small grants in aid of research in marine biology or oceanography at a recognized laboratory during the year June 1955–June 1956. Applications, accompanied by details of the proposed research, should reach the honorary secretary, Mr. N. B. Marshall, British Museum (Natural History), Cromwell Road, London, S.W.7, before June 13.

THE Underwater Explorers Club (2 Thames House, Queen Street Place, London, E.C.4) is sending an expedition to Cyprus to explore the sunken portion of the city of Salamis and to make underwater scientific investigations in the waters around the island and the eastern Mediterranean generally. The main party of eight members will remain in Cyprus until late autumn and will be supplemented by others from the Club for short periods throughout the summer.

A SYMPOSIUM on electromagnetic wave theory will be held at the University of Michigan during June 20–25, under the auspices of the International Scientific Radio Union. The papers will deal with the following topics: boundary-value problems of diffraction and scattering theory; forward and multiple scattering; antenna theory; and propagation in doubly refracting media in wave-guides. Further information can be obtained from the chairman of the symposium, Mr. K. M. Siegel, Willow Run Research Center of the Engineering Research Institute, Ypsilanti, Michigan.

THE second of the international powder metallurgy congresses sponsored by Dr. Paul Schwarzkopf, president of the American Electro Metal Corporation, Yonkers, N.Y., will be held at Reutte, in the Austrian Tyrol, during June 20–23, when the topic of high-temperature and corrosion-resistant materials by powder metallurgy will be discussed. Reutte has again been chosen because of the very large powder-metallurgy works there, the Metallwerk Plansee. About three hundred people from seventeen nations will be attending, including more than thirty scientific workers from Great Britain. Further information can be obtained from George Cohen, Ltd., 600 Group Publicity Department, Cunard Works, Chase Road, London, N.W.10.

THREE special summer courses will be held this year in the Massachusetts Institute of Technology as follows: June 20–July 1, switching circuits (under Prof. S. H. Caldwell and Dr. D. A. Huffman, of the Department of Electrical Engineering); June 20–July 8, current scientific developments concerned with foods and the food industries (jointly run by a number of members of the Department of Food Technology and others); and August 8–19, low-temperature engineering and research (under Prof. S. C. Collins, of the Department of Mechanical Engineering). Application forms and further information on these courses can be obtained from the Summer Session Office, Room 7-103, M.I.T., Cambridge 39, Mass.

THE Gordon Conference on Proteins and Nucleic Acids, under the auspices of the American Association for the Advancement of Science, will be held this year in New Hampton, N.H., during June 27–July 1. In the past, the programme has dealt largely with the physical-chemical properties or the metabolism of proteins, nucleic acids, and their building blocks; this year the theme will be the chemical and structural aspects of proteins and nucleic acids and will be concerned with the recent advances in the structure of biologically active polypeptides, insulin, ribonuclease, and some of the larger protein molecules. Further information can be obtained from the chairman of the Conference, Dr. Frank W. Putnam, Department of Biochemistry, University, Chicago 37, Ill.

WE regret that the report in *Nature* of April 23, p. 717, on an address by Sir Charles Morris on the University of Leeds, contains a mis-statement. Sir Charles said that work on the extension of the chemistry and physics buildings of the University began some weeks ago. It is expected that the first stage will be completed and ready for occupation by October 1958.

ERRATUM. In the communication "Chemical Effects of X-Rays upon Aqueous Solutions of Cortisone and Deoxycorticosterone" in *Nature*, April 23, p. 721, the abscissæ are marked "Dose (10^{8} eV./ml.)"; this should read "Dose (10^{18} eV./ml.)", as in the legend.

FUNCTIONS AND EDUCATION OF THE CHEMICAL ENGINEER IN EUROPE

A CONFERENCE on "The Functions and Education of the Chemical Engineer in Europe" was held during March 21–25 in the Assembly Hall at Church House, Westminster, London. It was organized by the Institution of Chemical Engineers in co-operation with the Department of Scientific and Industrial Research, on behalf of the European Productivity Agency of the Organization for European Economic Co-operation. At least thirteen European countries, Australia, South Africa and the United States were represented among the 350 who registered for the Conference, which owed its origin to a document entitled "Chemical Apparatus in the U.S.A." published in 1952 as a report on Technical Assistance Mission No. 23. This report directed attention to two points in particular: (1) the leading position in the chemical industry which the United States has acquired in recent years is to a great extent due to the rapid development of the profession of chemical engineering; (2) the importance of chemical engineering is generally recognized by the Government and by industry in the United States; but this is less frequently the case in Europe.

The three main objectives which the Conference under Project 297 of the European Productivity Agency was asked to explore were: (1) the necessity for more chemical engineers and more schools of chemical engineering in the universities and technical colleges; (2) the necessity for more financial support for chemical engineering research both in universities and technical colleges, and in specialized laboratories with support from government and industry; (3) the necessity for a more general recognition of the part that chemical engineering is bound to play in modern industry.

The Conference was opened by the Lord President of the Council, Lord Salisbury, and some introductory remarks were made by M. R. Gregoire, who is deputy director of the European Productivity Agency. It was divided into six sessions.

The first session, on "The Part played by the Chemical Engineer in bridging the Gap between Research and Plant Construction", was opened by Sir Christopher Hinton, managing director, Industrial Group, U.K. Atomic Energy Authority. The Authority, he said, has a series of people working on the design of a process plant, from the pure scientist at one end to the detailing mechanical engineering designer at the other, who need have little knowledge of the scientific principles which underlie the process. The chemical engineers fit into this scheme like bands in a spectrum.

The second paper, by Dr. K. Riess, a director of the Farbenfabriken Bayer A.G., Leverkusen, was on "The Process Engineer in the German Consumer Goods Industry". He remarked that the American method of training chemical engineers produces extraordinary versatility and "cannot but have the disadvantages of all compromise solutions because versatility is bought at the price of thoroughness". The third paper, on "The Function of the Chemical Engineer as a Link between Pure Research and its Industrial Applications", was by Dr. L. Morandi, vice-president of the Montecatini Co., of Milan, who pointed out that the chemical engineer effects the first control of an economic nature on the results of research. The next paper was by Dr. R. Holroyd, director of research, I.C.I., Ltd., on "Considerations of Technical Staff Requirements in the Evolution of an Industrial Chemical Project". Dr. Holroyd emphasized that, in bridging the gap between research and industrial production, overall responsibility must be vested in one department and preferably ultimately in one individual.

The final paper, by Mr. C. F. Kearton, a director of Courtaulds, Ltd., was on "The Chemical Engineer in a Man-made Fibre Industry". He said that the chemical engineers have grown into an accepted and valued group within his Company. He illustrated their work by reference to developments of a new chemical fibre, the improvement of a retort design in the manufacture of carbon disulphide and the erection and operation of the Company's new Alabama factory, which has exceeded its designed output.

The second session, on "The Chemical Engineer in Plant Operation and Management", was under the chairmanship of Dr. K. Riess, who is also chairman of the Verein Deutsche Ingenieure, Fachgruppe Verfahrenstechnik. The first paper was by Mr. J. A. Oriel, of the Shell Petroleum Co., president designate of the Institution of Chemical Engineers. He spoke from personal experience of the thrill of first operating a new petroleum plant and getting it on stream. The second paper, by M. N. Chorine, directeur des développements et recherches à la Société des Produits Chimiques Coignet, Belgium, was on "The Role of the Chemical Engineer in the Operation and Management of Chemical Plants". Development in Belgium, he said, has been rather slow; this he attributed to a lack of the technological spirit in chemistry. The next paper, by Dr. K. Winnacker, chairman of Farbwerke Hoechst A/G of Frankfurt, said that the experience of German industry was that it is better to divide responsibility, the chemist being responsible for quality and production and being assisted by the engineer, who draws up the plans for a new process and is responsible for its construction. The final paper, by M. E. Bognar, chef de la section de Génie Chimique de la Compagnie de Saint-Gobain, France, pointed out that the chemical engineer is the person best situated to co-ordinate the ideas of the research worker and the economist.

Dr. Vlugter, of the Amsterdam Laboratory of the Shell Company, presided over the third session, which was devoted to courses of study for a primary degree in chemical engineering. The first paper, by Prof. K. Schoenemann, of the Institut für Chemische Technologie der Technischen Hochschule, Darmstadt, Germany, discussed how far the traditional training of the chemist can be brought into line with recent developments. In Germany, in addition to the training of engineers in unit operations, the training of chemical technologists must be promoted.

The second paper was by Prof. T. R. C. Fox, Shell professor of chemical engineering, University of Cambridge. He considered the best way of fitting the training of chemical engineers, and indeed technological courses, into the general background of a university. Prof. E. Kirschbaum, of the Institut für Apparatebau und Verfahrenstechnik of the Technische Hochschule, Karlsruhe, gave details of the first full course for chemical engineers, held at his

College, which was inaugurated in 1928. Prof. J. Danze's paper on the training of chemical engineers also gave similar details for the chemical engineering course at the University of Liège. Prof. H. Kramers and Dr. P. M. Heertjes gave some notes on chemical engineering courses in the University of Delft.

Prof. K. G. K. Peters, of the Technical University of Vienna, said that chemical engineering should be based on profound chemical reasoning. He considered that its teachers should be well versed in both chemistry and mechanical engineering, which represent quite different worlds of ideas. The final paper of the session, by M. J. Givaudon, Ingénieur Conseil à l'Union des Industries Chimiques de France, stressed the importance of numerical calculations in undergraduate training.

Session IV dealt with other education schemes such as those for postgraduate and part-time students; Prof. F. H. Garner, of the University of Birmingham, presided. Mr. C. J. Borelius, of the Svenska Skifferolje Aktibolajet, described the development of chemical engineering in the Kungl. Tekniska Högskola in Stockholm and the Chalmers Tekniska Högskola in Göteborg; unfortunately, both professorships are vacant through lack of suitable applicants.

Prof. M. B. Donald, Ramsay Memorial professor of chemical engineering, University College, London, and Prof. J. M. Coulson, professor of chemical engineering at King's College, Newcastle upon Tyne, jointly introduced a paper on the postgraduate course for providing training in chemical engineering for those who already have a degree in chemistry, physics or mechanical engineering. Such courses have been available for some thirty-three years in Britain, and form the basis for the development of the undergraduate course.

Prof. S. G. Terjesen, of the Norges Tekniske Hogskole, Trondheim, the editor of the previous O.E.E.C. report (No. 23), spoke of the methods and theory of process control in chemical plants, and the knowledge that a chemical engineer should have of these subjects to enable him to deal with the ever-increasing instrumentation of chemical processes.

Mr. R. W. Blount, staff inspector of the Ministry of Education, spoke of the part-time course in chemical engineering leading in Britain to a Higher National Certificate. He pointed out that these schemes are unique in so far as they are fostered only in Britain. These examinations and courses provide a very convenient method for taking the examinations of the Institution of Chemical Engineers. The establishment of some 'sandwich' schemes, in which the student spends periods alternately at a college and in works, instead of one day or so a week over a long period, would probably help in recruitment for these courses.

The final paper, by Dr. G. U. Hopton, of the North Thames Gas Board and chairman of the Board of Examiners of the Institution of Chemical Engineers, was on the associate membership examination of the Institution. He showed that it places no undue limitation on those who are eligible for entry, and that it has recently been reorganized to ensure that applicants are more adequately fitted as members as the science of chemical engineering progresses. He finally directed attention to the design problem feature of the examination, where the student is expected to design a chemical plant from first principles and where he encounters most of the types of problems which he would be likely to meet later in his career.

The practical training or apprenticeship of the chemical engineer after graduation was considered in the fifth session, under the chairmanship of Prof. M. Letort, directeur de l'École Nationale Supérieure des Ind. Chim., Nancy.

Mr. F. H. Pugh, of De Bataafsche Petroleum Maatschappij, gave details of a scheme which has been worked out for training in refinery operation. Previously, with a haphazard scheme, the results had been uneven; but, now that it has been set on an organized footing, both the firm and the apprentices have gained considerably. This paper was followed by another one from representatives of a firm which manufactures plant, by J. P. V. Woollam and J. M. Solbett, of Simon Carves, Ltd.

Mr. D. Morten, of the Shell Refining and Marketing Co., Ltd., described the use of sponsored courses for training students before entry into industry. For the past three years, these courses have been conducted during the university long vacation. The students are accompanied by a tutor (one of their senior lecturers), and the refineries are now certain that the students gain extra value from this course. The presence of the tutor lightens the load on the refinery staff, who are then free to give specialist lectures on industrial management problems.

Mr. J. Newby, the secretary of the International Association for the Exchange of Students for Technical Experience, then told of the remarkable growth of this organization for broadening the knowledge and culture of technical students. Since it was founded in 1948 with ten member countries and 920 students, it has grown to nineteen member countries and 4,267 students in 1954. In the years 1950–54, the chemical engineering students taking advantage of travelling abroad under this scheme amounted to 1,285 out of a total of 18,000.

The chairman of the final session was Sir Harold Hartley, president of the Institution of Chemical Engineers, and the topic discussed was research.

Prof. J. Cathala, director of the Institute of Chemical Engineering, University of Toulouse, produced an interesting classification of possible research subjects and made the following remark: "The Cremer report published in 1951 is a most remarkable work, which once again bears witness to the efficiency of our British colleagues when they form a committee for study purposes". Dr. H. Miessner, of the Farbenfabriken Bayer AG, Leverkusen, described the organization of the VD1-Fachgruppe Verfahrenstechnik into thirteen groups for the study and development of research problems. Mr. A. S. White, head of the Chemical Engineering Department of the Atomic Energy Research Establishment, Harwell, said that one of the lessons to be learnt from the development of nuclear engineering is that a considerable quantity of essential information is lacking for design purposes; this provides a powerful incentive for more basic research to be undertaken on the subject. Prof. S. Kiesskalt, director of the Research Institute for Process Technology of the Rhine–Westphalian Technische Hochschule at Aachen, described the work done in his new research station (which is of the type envisaged by the Cremer report and which has, unfortunately, not yet been implemented in Britain).

Prof. P. M. Heertjes, of the Nijrerheids Organisatie TNO of The Hague, advocated that financial policy for research should be on a long-term basis to provide the research worker with greater freedom.

The final paper was by Prof. D. M. Newitt, Courtaulds professor of chemical engineering in the Imperial College of Science and Technology, London, who discussed the scope and nature of the research which can appropriately be undertaken in a teaching department of chemical engineering.

The final summing-up of the results of the Conference was made by Sir Harold Hartley, who said: "What has become abundantly clear to me as the days progressed is that, with one partial exception, there is a general agreement among the European countries represented here as to the conception of chemical engineering as a fourth primary technology which now takes its place alongside the other professions of civil, mechanical and electrical engineering. And I know that that view is shared by all the countries of the British Commonwealth. That is the first major result of our Conference and it is one of great importance. We did not know until now the degree of unanimity that existed between us. The second result is to show that there is a large unsatisfied demand for chemical engineers, and consequently a need to expand and multiply the schools of engineering in each country . . . we have already examined the need for more research and the lines on which it should proceed and the advantage of closer co-operation between us. So we have answered two questions put to us in the affirmative. For the third we must rely on the Press, and I hope that our nomenclature has not been too technical to obscure the main issues".

Coming to the partial exception, he said: "Let me begin by expressing our admiration and our indebtedness to Germany for what she has contributed in the field which we like to call chemical engineering. Let me remind you of what the world owes to Adolf Baeyer and Emil Fischer and their pupils and to the Haber process, of those great pioneer developments of the synthetic industry in Germany around about 1900. I shall never forget the impression made on me by the imaginative chemical engineering of the Haber plant at Ludwigshafen when I first saw it. Now our German friends, for good reasons from their experience, have chosen rather a different approach to us. Let me say at once that we admire the skill of their Verfahrens Ingenieure, which is seen to such advantage in the mechanical design of their plants. We could do with more of that same breed in other countries, particularly in the field of plant manufacture. Their Verfahrens Ingenieure represent one band in Sir Christopher Hinton's spectrum, or one arm of Prof. Donald's distribution curve. I must say that I was greatly comforted by what Prof. Schoenemann said of the need to supplement the classical chemist by the chemical technologist, and how unfortunate it would be if the need for process engineers were to hinder the technological education of a number of chemists. Thereby he is building a bridge between our different approaches. Chemical engineering is still a very young profession; it is dynamic and it is in the stage of rapid evolution. So it is no wonder that there are different patterns, and it is all to the good that it should develop on independent lines in different countries and universities. It is its adaptability and its flexibility that are its great strength. As Mr. White said, its ubiquity is its most marked characteristic. Its techniques are invading almost every industry and the hope of satisfying the world's growing demands depends more and more on chemical engineering, call it by what name you will".

INSTITUTE OF PHYSICS EDUCATION GROUP CONFERENCE

At the annual conference of the Education Group of the Institute of Physics, held on April 14 and 15, with Dr. J. Topping as chairman, the teaching and applications of thermodynamics, and the place of physics in a liberal education were the subjects of the main contributions.

Prof. E. A. Guggenheim (University of Reading), speaking on "Fundamentals of Thermodynamics", said that the first concept for the beginner should be free energy, and the subject should be developed from the Gibbs–Helmholtz equation, which would be presented as an axiom in a purely classical treatment, or as a consequence of the distribution law in terms of statistical mechanics. Entropy, and the distinction between reversible and irreversible changes, should not be introduced too early. The student should proceed in stages from simple isothermal reversible cases, working always in terms of decrease in free energy rather than of entropy increase.

The achievements and problems of the heat engineer were described by Dr. G. G. Haselden (Imperial College of Science and Technology, London) in a paper on "Thermodynamics in Industry". The development of new materials for high temperatures at which the heat acceptance of an engine can match the heat liberation of the fuel, the search for cycles more efficient than those based on the constant-temperature evaporation of water, and the choice of the best cycle for the gas turbine, are among the applications of thermodynamics to large-scale power generation. Also, by exposing the low efficiency of the turbine system, thermodynamics has stimulated the search for the fuel cell, which has already, so far as gaseous fuel is concerned, reached a promising stage. While the seasonal fluctuation of the heat-pump's output and its high capital cost make it uneconomic as an ordinary means of heating in Britain, it is more attractive in chemical industry, to bridge the small interval between the temperatures at which heat is given out by one process and absorbed by another, as, for example, in a sugar evaporation cycle.

In designing air liquefaction and separation systems, the components are matched to the properties of air (to eliminate discontinuous latent heat jumps) as in the Heylandt process, where the expansion engine operates in the supercritical region, and the interchanger below it. Ideally, heat should be supplied and extracted at every level in an air separation column, and heat pumping is now used for supplying or extracting in several places instead of at the extremes. Following Ruhemann's analysis of the entropy increases at various stages of the Linde system, the aim is to approach reversibility at each stage. As a result, air-separating plants have been made which operate at an efficiency of 23–25 per cent, compared with a theoretical efficiency of 35 per cent and the 12 per cent of the original Linde double column.

Opening a discussion on the teaching of thermodynamics, Prof. M. W. Thring (University of Sheffield) outlined the organization of classes for various groups at the University of Sheffield, and mentioned the importance of the emotional attitude towards the subject, and its various functions. Free energy is a 'good' function, and entropy a 'bad' function the increase of which is to be discouraged—gain of

entropy by a system representing a positive loss of virtue. Clarity is necessary in distinguishing between the 'first-law' efficiency of a system and the thermodynamic efficiency. Dr. N. Kurti (Clarendon Laboratory, Oxford) deplored the conventional distinction between heat and thermodynamics, and suggested that a single course, implanting faith in thermodynamics by the statistical approach, should serve for all university students whatever their specialist interests. Dr. R. S. Silver (John Brown Land Boilers, Ltd., Clydebank) presented the practical engineer's point of view. Thermodynamics, he said, is badly taught because its concepts are of a subtlety beyond the grasp of the average physicist and the average teacher. Hence, the exposition of the second law is not normally adequate to equip the engineer to face industrial problems. He advocated teaching in terms of ordered and disordered energy rather than work and heat—ordering rather than energy conversion—and abandoning the usual idea of efficiency for a proportioning ratio between ordered and disordered energy expressed in terms of temperatures.

Dr. A. W. Barton (City of London School) opened the second day's proceedings, speaking on "Physics in the School Curriculum". The historical development of the subject is a treatment which marches in line with the development of the individual boy, with the early passion for collecting facts and slowly emerging capacity to relate them to general principles. Physics is, he said, an educational discipline equalled only by Greek. Dr. Barton's lively exposition of his own teaching methods was a memorable feat, which illustrated his general argument convincingly.

Mr. W. Llowarch (Institute of Education, London) spoke on "Non-Specialist Science in the Sixth Form", outlining the scheme he developed during his time at Stowe School. For a year's course, the boys were divided into three groups, each doing one term of biology, physics and chemistry in rotation, the work being taught by specialists. Lectures on isolated subjects of special or topical interest had proved on the whole preferable to a more continuous course, and biology seemed the most generally appreciated of the three. After discussing the aims of the course, Mr. Llowarch gave some examples of topics which had been particularly successful.

"Education through Physics" was the title of the talk by Prof. F. A. Vick (University College of North Staffordshire). One of the aims of education, he said, is to toughen the mind by exercise on problems. The historical approach, while not generally useful, can be valuable in showing the devious routes by which accepted theories arose. Students should be encouraged from the beginning to consult original papers, and in the final year at the university, while continuing a broad education, should reach the frontiers of knowledge in one or two places. In subsidiary physics courses, the future technologist should regard the subject not as a mere tool, but as a contribution to his full education. Prof. Vick regards physics, freed from the mechanistic outlook of the nineteenth century, as a living subject which stands equal to classical and modern studies as the core of a complete education.

Mr. N. R. Hanson (University of Cambridge) then described the undergraduate course in the history and philosophy of science, developed during the past five years in the University of Cambridge. The aim, he said, is not to humanize the scientist by superposing a little culture, but to help him to understand what he is doing. History leads to a better appreciation of an idea by tracing the steps in its development. Philosophy, as concerned with the meaning of concepts, and why they are fashioned in one way rather than another, may help a man to be a better physicist. Mr. Hanson explained the close collaboration by which the course is dovetailed with the tripos lectures in physics, and spoke of the enthusiasm with which it has been received, and the growth of the Philosophy of Science Club at Cambridge.

G. R. Noakes

PROPOSED MUSEUM OF SCIENCE AND TECHNOLOGY IN THE NORTH-WEST OF ENGLAND

A MEETING was held on February 18 at the College of Technology, Manchester, to consider a proposal to establish a museum of science and technology in the north-west of England. Interest in such a museum came from a number of quarters—from industry and from academic and educational life. Sympathy and support for this scheme has also been shown by municipal and other bodies. The meeting was attended by representatives of industry, the universities, trade and professional bodies and representatives of museums in Manchester, York, Birmingham and Liverpool.

A resolution was moved by Mr. L. Lever, M.P., and Dr. P. F. R. Venables, and carried unanimously, that a museum of science and technology be established, and an executive committee be appointed in order to investigate the details involved in setting such a project in action, and to report back at a subsequent meeting of the body as then constituted. The executive committee consists of Mr. H. G. Greg (for the Textile Institute), Mr. Niel Pearson, Prof. L. Rosenfeld (Department of Theoretical Physics, University of Manchester), Mr. R. M. Sayce (keeper, Manchester Museum) and Dr. P. F. R. Venables (principal, Royal Technical College, Salford); Mr. P. Lennox-Kerr (editor, *Skinner's Silk and Rayon Record*) and Dr. W. Mays (Department of Philosophy, University of Manchester) are the joint secretaries.

The project for a museum of science and technology arose from the joining together of two streams of interest. In industry, especially the textile and engineering industries, there has for a long time been felt the need for establishing an industrial museum to take account, among other things, of the economic history of the region. At the University of Manchester there was a group of people interested in the establishment of a museum for the history of science and technology. It was felt by them that the history of science should take a more important place in university education, where there is an ever-increasing need for relating the diverse fields of study which make up the university curricula. In the promotion of the study of the history of science, a museum plays an essential part, comparable to that of a laboratory in the experimental sciences.

The intention is to establish a science museum which will show the development of industry in the north-west of England from the early days of the Industrial Revolution to the present day in relation to the scientific background. It is hoped that it will embrace a number of fields of inquiry—from the natural sciences to economic history—and lead to

their integration, and in this way provide a link between industry and the academic world.

Such a museum can act as a repository of documents and objects of great historical value, which otherwise run the risk of disappearing through decay or neglect. It is hoped that when established it will be a centre of research where the impact of the sciences upon each other and upon technology can be studied. Its activities would cover pure science, discovery and invention, and manufacture and use. Future developments and sociological implications would be taken into account. There are already clear indications that the proposed scheme is of public, as well as specialist, interest. As well as covering the history of science it will endeavour to acquaint the general public with the most recent scientific advances and their industrial applications.

At a time when technical knowledge is becoming increasingly important, such a museum can play a vital part in modern education. Early introduction to large areas of scientific knowledge and its application is desirable if we are to prepare young people to enter such fields of study. Bringing young people into such an institution would give them a chance of tracing the evolution of specific representative manufacturing processes from hand processes to modern automatic equipment, and stimulate in them the desire to play a part in the continuation of such developments. It has been suggested that a preliminary exhibition be held to indicate the scope of the museum, and to interest the public in its activities.

CARNEGIE TRUST FOR THE UNIVERSITIES OF SCOTLAND

REPORT FOR 1953–54

THE fifty-third annual report of the Carnegie Trust for the Universities of Scotland, covering the year ended September 30, 1954*, records increasing preoccupation of the Executive Committee with appeals for assistance from students who have been deprived of their bursaries by the local education authorities through failure to pass the requisite degree examinations at the appropriate times. In all but the most exceptional cases, the Trust's assistance is limited, however, to the class fee, and no maintenance grant can be made. In the year under review, the number of students assisted increased from 1,301 to 1,408, almost entirely in science and medicine, the amount expended increasing from £20,003 to £22,007. While the Executive Committee recognizes that, with the length and expense of the courses in dentistry and medicine, many students, despite substantial bursary awards from education authorities, are severely taxed to make ends meet, it points out that, particularly where an education authority bursary is held, there can be no assumption that additional assistance from the Trust is automatically forthcoming. Every application is considered on its own merits, and clear evidence of need must be shown.

Expenditure on the research scheme increased by about £2,000 to just short of £35,000, and the Executive Committee regards the scheme as continuing to yield satisfactory results. While no upper limit has been fixed for the sum expended on fellowships, scholarships and grants, in practice the amounts required have not varied significantly from year to year. Certain other limits are at present fixed by annual decision: these include £4,000 to the universities for distribution at their discretion to lecturers and professors engaged in research projects at home and abroad; £500 to the Royal Society of Edinburgh; and £6,000 to the scheme by which not more than ten senior members of the staffs in the universities are afforded an opportunity of three months or more to pursue their research investigations abroad. Uncertainties as to expenditure lie rather in the growing region of guarantees against loss on publication of books of a kind that might have great difficulty in getting acceptance by a publisher.

Besides details of grants made under the ninth quinquennial distribution (October 1, 1952–September 30, 1957), the abstract of accounts, lists of publications by fellows, scholars and recipients of grants received since September 1953, of papers assisted by grant for the session, and of fellowships, scholarships and grants under the research scheme, there is appended the usual report upon the work of investigators under the research scheme during the year. In the mathematical, physical and engineering section, high praise is given to D. M. Colvin's high-pressure ionization chamber investigations and to W. D. Munn's work on problems relating to abstract algebra; K. M. Swanson has made steady progress in his study of nuclear magnetic resonance effects in semi-conductors, and Dr. E. Wolf, as a result of his study of interference and diffraction of light, has proceeded to a research fellowship at the University of Manchester. In medicine, I. A. Macpherson's work on the development of tissue-culture methods in the study of poliomyelitis and Jean D. Garven's work on the estimation of 5-hydroxytryptamine in extracts of animal tissues are specially mentioned.

In the chemistry section, Dr. T. R. R. McDonald's X-ray crystallographic investigation of ammonium bifluoride, which confirmed views assuming a resonance state for the bifluoride ion and afforded no evidence of interaction between the fluorine and the hydrogen atoms of the ammonium ion, is specially commended. Mr. R. Logan's investigation of phosphate metabolism in the rabbit, using radioactive phosphorus as indicator, showed that under *in vitro* conditions the cell nuclei of rabbit liver take up phosphate from the cytoplasm. Similar results were obtained with the spleen and the intestinal mucosa; but no evidence of the reverse passage was obtained in the liver or the spleen, although a small but significant transfer occurred in the intestinal mucosa. Reference is also made to the work of A. N. Hamer, D. Calvert and R. C. Taylor at the University of St. Andrews on the construction and use of apparatus for applying mass-spectrography to the measurement of ionizing potentials and identifying products of pyrolysis of organic compounds. L. R. Newlands has obtained a series of triazole compounds by the action of aromatic aldehydes on a new derivative of mandelic acid obtained from mandelic amidate hydrochloride and phenylhydrazine. C. A. J. Goodlad's work on the enzymes of rat liver which hydrolyse phosphoric esters of sugars has demonstrated the complex nature of these phosphatases. In the biological section special mention is made of G. D. Scott's work on the ecology and physiology of lichens, which has demonstrated the possibility of growing the fungal constituent of a lichen in pure culture, and of that of J. Weir on the ecology of the

* Carnegie Trust for the Universities of Scotland. Fifty-third Annual Report (for the Year 1953–54). Pp. iv+72. (Edinburgh: T. and A. Constable, Ltd., 1955.)

ant *Myrmica*. In geology and geography, continued progress is reported in the study of important fossils from the coal measures, in J. Phemister's gravimeter survey of the Highlands of Scotland, and W. C. Jardine's work on the relation between shore-lines and river-valley development, with particular reference to the Southern Uplands of Scotland.

EUROPEAN PRODUCTIVITY AGENCY

A RECENT issue of the Information Bulletin of the European Productivity Agency of the Organization for European Economic Co-operation describes the work of the Agency's Human Factors Division (6–7 ; December 1954–January 1955).

The Human Factors Division was the last of the five operational divisions of the Agency to be developed, and has not yet reached its final shape and structure. It deals with those human aspects of productivity which are the daily concern of men and women at all levels in industry.

Three sections of the Division were envisaged to cover three aspects of its work : man as an individual ; man as a member of a group or a number of groups ; and, thirdly, man as a member of a trade union.

The first aspect of the work in the Division impinges on a variety of sciences and technologies, including physiology, psychology and production engineering, and covers the adaptation of machinery and physical conditions of work to the obtaining of optimum results. This field of research is better known and more highly developed in Europe than others with which the Division has to deal, and the Division therefore tends to concentrate on encouraging and supporting the work of local, national and international institutions which have already specialized in this research. Where such institutions do not exist, the Division aims at encouraging their creation.

The second section of the Division's programme deals with the sociological aspects of productivity. It is concerned not only with techniques, but also with educational processes. In sociological problems of work, Europe is, in general, behind America. In this field, the Division will have the task of encouraging original research work and education by organizing visits to America by young men or experts from Europe who have already begun to study these subjects, and by similar visits from one European country to another. Congresses and seminars are being organized and American consultants are being appointed to disseminate in Europe the best results of American learning and practice. For example, the recognition given to the importance of the foreman and his training in technical and social skills has not been widely accepted in Europe or its consequences fully recognized. The tendency to concentrate attention on recently developed industries, particularly the manufacturing industry, has meant that the human problems of utilities and commercial firms have been overlooked. The Division is also interested in such public services as railways, and one of its projects aims at organizing a pilot analysis of human factor problems in the railways of Europe. Study will also be undertaken of office work in banks, insurance companies and commercial firms.

The third section of the work of the Human Factors Division is concerned with trade unions and trade unionism in general. What distinguishes this so-called section from the others is the method of approach. It tries to bring to the door of trade union organizations in Europe the techniques, ideas and principles which are the basis of productivity in general. If the drive for European productivity is to be effective, it must involve not only the enterprises, the managers, the head men of European industry ; it must also reach the workers.

Some of the activities in this section are of a direct educational nature. Others tend to place at the disposal of trade union organizations in various countries all the information which can be found in every field, either in America or in Europe. Lecturers and American consultants who are themselves experienced trade unionists are recruited so that they may share their experiences and discuss them with their European colleagues. European consultants and lecturers, who form a panel arranged within the Division, are ready to organize courses for European trade unionists.

The work of this Division is not in any sense isolated from the work of the other divisions of the Agency. A division with which the Human Factors Division has to work in close unison is the Business Management Division. Another is the Economic Factors Division, which is concerned more specifically with economic problems. Yet another is the Agricultural Division, where human factors are just as important as they are in industry. In short, the Human Factors Division is at the service of the Agency as a whole, for the human element can never be dissociated from productivity.

THE PSYCHOLOGIST AND PERSONNEL MANAGEMENT

DISCUSSING the role of the psychologist in personnel management, Dennis McMahon suggests that the psychologist is useful to the personnel manager because he is trained and experienced in tackling personnel problems in a scientific fashion. 'Scientific' has nothing to do with apparatus and relatively little to do with specialized knowledge ; it has to do with approach, with method (*Personnel Management*, **37**, No. 331 ; March 1955).

Sketching the way in which occupational psychology has developed in recent years, McMahon shows that in the 1920's and 1930's the topics engaging the attention of psychologists were work-study, training, selection, lighting and fatigue. Attempts were made to generalize from the results that were achieved, but these broke down ; what was applicable in one industrial situation was totally inadequate in another. Human factors often arose which completely nullified the results of carefully planned scientific experiments.

Despite this, some recent researches in the field of employee relations have produced results which stand up as 'general findings' in industrial situations. These are few and fall into the category of 'blinding glimpses of the obvious'. Among them are the following :

(1) Workers who are kept informed of how they are doing, who have knowledge of results, do better than less intelligently treated workers.

(2) Success follows the supervisor : when supervisors have been moved around, production-rates tend to be moved around with them.

(3) Supervisors who are employee-centred get more out of their workers than do the autocrats, or the more technically minded supervisors.

(4) On the whole, small working groups or teams do better than large ones.

(5) Workers who complain about the canteen and other things are usually complaining about something else but have displaced their resentment on to a handy 'whipping-boy'.

(6) Groups which set their own production targets after free discussion do better than groups which have their goals set for them—even when the setting has been done by enlightened and kindly masters.

STRENGTH OF THE SHELL OF THE HEN'S EGG

By Dr. J. BROOKS and H. P. HALE

Low Temperature Station for Research in Biochemistry and Biophysics, University of Cambridge, and Department of Scientific and Industrial Research

LITTLE is known about the strength of an egg except that for eggs of the same species there is no relation between size and strength, and that differences in strength can be only partly explained by differences in the thickness of the shell[1]; further work was therefore undertaken. A constantly increasing load was applied at the rate of 100 gm./sec. to an egg lying lengthwise between two parallel plates of polished hard brass with a Vickers hardness number of 185 kgm./sq. mm. The apparatus recorded the increasing load (w) applied to the egg at the two opposed points on its equator, and the diminution in distance (d) between the two plates during loading. The apparatus ceased to record when the shell fractured, thus giving w_c and d_c at the instant of cracking. The extent of deformation (d) was recorded 120-fold on a chart. The relation between w and d for a single egg was linear or nearly so. For loads short of w_c, the deformation was almost entirely recoverable on removing the load. Unless otherwise stated, all the relations mentioned below were highly significant ($P < 0.001$).

The results with 365 hen eggs ranging in weight from about 45 to 65 gm. are summarized in Table 1 (where t denotes the thickness of the shell in the region where the crack started). Most of the measurements were made on samples of 36 eggs drawn at random from larger batches obtained from different sources at different times of the year. There was little difference between samples, but large differences within samples. For example, sample means for w_c/t ranged from only 10·5 to 11·6 kgm./mm., whereas the range for individual eggs within a sample might be as large as 8–15 kgm./mm.

Correlation coefficients are given in Table 2. The value of the coefficient for w_c with t is as great as, or greater than, that reported by other workers; even so, only about 58 per cent of the variance can be explained by differences in shell thickness. The scatter of the results was so great, in fact, that they could be almost equally well expressed by relating

Table 1

Property	Mean	Standard deviation
w_c (kgm.)	3·66 ± 0·042	± 0·802
t (mm.)	0·329 ± 0·002	± 0·0382
w_c/t (kgm./mm.)	11·05 ± 0·088	± 1·68
d/w (mm./kgm.)	0·0475 ± 0·00061	± 0·0117
d_c (mm.)	0·167 ± 0·0015	± 0·0287

Table 2

Relation	Coefficient (r)
$w_c : t$	+ 0·761 ± 0·022
$w_c : t^2$	+ 0·757 ± 0·022
$w_c : d/w$	− 0·714 ± 0·026

w_c to t^2 (cf. Table 2). The value of w_c/t tended to increase with increasing shell thickness.

The correlation between w_c and the slope of the d–w curve was unfortunately not pronounced enough for prediction purposes; if it were, w_c could be measured without cracking an egg. Nevertheless, by applying the same load—short of w_c—to a number of points around the equator of the same egg, it was possible from the values of d to show that the differences within a single egg were too small to account for the differences between eggs. There was no relation between w_c and the size of the egg; but its shape had a slight influence, w_c/t tending to increase with increasing symmetry (r equalled + 0·33 when the breadth of the egg divided by its length was taken as a measure of symmetry). No relation was found between strength—as represented by w_c or w_c/t—and the average number of pores in a unit area of the shell.

When the shell was suitably blackened by an extremely thin coating of silver or by staining it with Verhoeff's stain, a rough estimate of the pressures sustained during loading could be obtained by measuring microscopically the total area of the numerous high lights presumably formed by the plastic deformation of the tips of minute asperities on the shell by the harder plates. The results obtained by applying a number of loads to different regions on the shell of the same egg are set out in Table 3.

Table 3

w_c = 4·75 kgm.; t = 0·41 mm.

Region	Top plate				Bottom plate			
w (kgm.)	2·30	3·17	4·03	4·75	2·30	3·17	4·03	4·75
Area of contact (sq. mm.)	0·21	0·26	0·45	0·58	0·21	0·34	0·54	*
P (tons/sq. in)	10·9	12·2	8·9	8·2	10·9	9·3	7·5	*

* Egg cracked

An egg can sustain high pressures without cracking, and it is probable that the values in the table are under-estimates. The shell appears to resemble metallic surfaces in that the real area of contact is nearly proportional to the applied load[2]. Only a very small proportion of the observed values of d was derived from the plastic flattening of surface irregularities, the remainder being derived from the elastic deformation of the shell as a whole.

Using large or small values of w_c/t as a criterion of unusual strength or weakness, the strongest ten and the weakest ten eggs were selected from a sample of seventy-two. For each egg the Vickers hardness number of five transverse sections of the shell near the start of the crack was measured with a G.K.N. microhardness tester using a load of 100 gm. Three rows of six impressions were made on each section parallel to the inner edge of the shell, and at distances from it of $\frac{1}{4}t$, $\frac{1}{2}t$ and $\frac{3}{4}t$. A rough estimate of brittleness[3] was obtained by measuring microscopically the area of superficial shattering that sometimes adjoined the pyramidal impressions. The remainder of the shell and its adhering membranes were analysed for nitrogen (membrane, pore and matrix nitrogen[4]), calcium, magnesium, sodium and phosphorus. Analyses for carbonate, potassium, aluminium and iron were started but abandoned; the carbonate

Table 4

Shells	Vickers hardness number at level: t	w_c/t	$\frac{1}{4}t$	$\frac{1}{2}t$	$\frac{3}{4}t$	m	Per cent impressions with shattered regions	Average area of shattered regions (sq. μ)
Strong (10)	0·35	13·4	99	113	130	176	5·7	350
Weak (10)	0·31	9·0	95	105	116	130	16·2	440

Parts for 100 parts of protein-free shell*

Shells	Ca	Mg	P	Na	Membrane protein	Pore protein	Matrix protein
Strong (10)	39·0	0·440	0·137	0·076	3·71	1·05	0·96
Weak (10)	38·9	0·386	0·141	0·069	4·01	1·13	0·98

* Percentage nitrogen = percentage protein × 0·14

content was equivalent to the sum of the calcium and magnesium contents, and the amounts of the other cations present were judged to be too small to be important. The mean results are set out in Table 4; m denotes the gradient of hardness across the shell.

Statistical analysis showed that there was a highly significant difference between the hardness of the two sets of shells at all three levels. The gradient of hardness (m) across a shell was linear or nearly so, and it was significantly greater ($P < 0{\cdot}01$) for strong shells. The softer a portion of the shell, the more brittle it tended to be; when impressions were accompanied by shattering, there was a significant correlation ($P < 0{\cdot}01$) between the Vickers hardness numbers and the areas of shattering. The outer part of the shell is surprisingly hard, being comparable in this respect to mild steel[3]. The hardness of the inner part of the shell resembled that of a sample of marble (mean Vickers hardness number, 98 kgm./sq. mm.); but it is doubtful if the comparison is a valid one since the lattices of the calcite grains of the shell, unlike those of marble, possess some degree of orientation with respect to the surface[5], and it is known that the various lattice planes of calcite differ in hardness[6,7].

For comparative purposes, it is convenient to extrapolate the hardness values for each egg to the outer surface of the shell to give H. Correlation coefficients for the twenty shells are given in Table 5; much of the difference between these shells can be accounted for if it is assumed that w_c is proportional to both the thickness of the shell and the hardness of its outer layer. That other factors are also involved is suggested by the magnitude of the coefficients, and the fact that some unusually thick shells are weaker than would be expected from their hardness and thickness. The mean values of H_t were 144 and 125 for strong and weak shells, respectively.

Table 5

Relation	$w_c : t$	$w_c : H$	$w_c : t^2$	$w_c : tH$	$w_c : t^2H$
Coefficient (r)]	0·249	0·740	0·825	0·906	0·891

Of the analytical values, only those for the magnesium content showed a significant difference ($P < 0{\cdot}01$) as between the two sets of shells. The shells of eighteen 'average' eggs (range of w_c/t = 11·0–11·6) from the same batch were powdered and mixed; the mean magnesium content was 0·409 per cent as against 0·440 and 0·386 per cent for unusually strong and weak shells, respectively.

If there is, in fact, a relation between strength, hardness and magnesium content, it would be expected that the gradient of hardness across the shell would be accompanied by a gradient of magnesium content. This was found to be so when shells were dissolved away in four or five successive layers with a mixture of perchloric acid and alcohol. The magnesium–calcium ratio decreased approximately logarithmically with increasing distance from the outer surface over about two-thirds of the thickness of the shell; thereafter, the gradient decreased. The inner third of the shell covers roughly the mamillary layer—which has a very different physical structure from the rest of the shell. The results of one experiment are set out in Table 6.

Table 6

Distance of centre of dissolved layer from inside of shell (thickness of shell = 100)	Mg/Ca ratio (values in gm.)
14	0·00605
38	0·00683
56	0·0103
73	0·0146
91	0·0196

These results are suggestive; but they do not prove that there is a direct connexion between magnesium content and the physical properties of the shell. As w_c/t tends to increase with increasing shell thickness (cf. Table 4) there will, in any event, be a tendency for the stronger shells to contain on the average a higher concentration of magnesium as a consequence of the gradient of magnesium content. It is true that dolomite is harder than calcite, and that magnesite is harder still[6], but it is not known whether the magnesium in the shell is actually substituted for calcium in the lattice of the calcite grains. The atomic Mg/Ca ratio approached 0·048 at the surface of a thick shell, and this value is close to the limit (about 0·05) for the random–substitution series starting with calcite[6]. Nor is it known if substitution within these limits would account for the range of hardness observed in the shell. Other factors which may be important in this respect are the influence of grain-size and of the properties of grain-boundary films on hardness and brittleness[8].

A detailed report of this work will be published later. We are indebted to Dr. J. Nutting and Mr. G. C. Smith, of the Department of Metallurgy, Cambridge, for much helpful advice, and to Dr. J. Wishart, in whose laboratory the statistical computations were made. Mr. A. Snow designed and made the loading apparatus; Mr. J. B. Monsey and Mr. N. R. King assisted in the experimental work. The work forms part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. [Jan. 10

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Characterization and Genetics of Hæmoglobin G

In the course of a survey of Gold Coast Africans[1], one individual was discovered who had both normal hæmoglobin and one hitherto not known which was designated as hæmoglobin *G*[2]. Hæmoglobin *G* was found to differ from all other known hæmoglobins in its mobility on paper electrophoresis at *p*H 8·6 (veronal buffer). The hæmoglobins most similar in mobility were sickle-cell hæmoglobin (*S*), fœtal hæmoglobin (*F*) and hæmoglobin *D*. *S* could in addition be differentiated by its low solubility when in the reduced state, and *F* by its resistance towards denaturation by alkali. For the distinction from hæmoglobin *D*, reliance had to be placed on the reported mobility of the latter, which was exactly that of *S* in open-boundary electrophoresis at acid and at alkaline *p*H[3]. Further steps have now been taken to establish the properties of hæmoglobin *G*.

Comparison between G and D. By the kindness of Dr. Sturgeon, a sample of hæmoglobin consisting of types *A* and *D* has been made available from a member of the Los Angeles family in which hæmoglobin *D* had originally been discovered[4]. This mixture had now been found to behave, as on open-boundary electrophoresis, so on paper electrophoresis at *p*H 8·6, exactly like a mixture of *A* and *S*[5]. It was possible to confirm that *D* behaved like *S* and differed from *G* under the conditions of our experiments.

Free-boundary electrophoresis. A mixture of hæmoglobins *A* and *G* has been examined both at *p*H 6·5 in cacodylate buffer and at *p*H 8·6 in veronal buffer. At acid *p*H good resolution occurs, and when the speed of migration of hæmoglobin *G* is measured, it lies between those observed for hæmoglobins *A* and *S*. If *S* is added to the *AG* mixture, difficulties are experienced in the resolution of *G* and *S*. No good resolution occurs between *A* and *G* at alkaline *p*H; but if *S* is added, there is good resolution between the *AG* mixture and *S*.

Family study. There is strong evidence that hæmoglobins *A*, *S*, *C*, *D* and *E* are the products of a single series of allelic genes, and that each of the two genes in the genotype is represented by part of the hæmoglobin in the red cells. It was therefore of interest to investigate the family of the propositus, J. R. A., on whom a brief report had appeared in 1954[2]. The mother had normal hæmoglobin only (genotype *AA*) and the father only hæmoglobin *G* (presumed genotype *GG*) (Fig. 1). The discovery of what appeared to be a homozygote was fortunate, because if hæmoglobin *G* was the product of a further allele of the series just mentioned, one would expect all the offspring of this homozygote to carry the abnormal hæmoglobin. He has eleven living children who are said to be legitimate, one of them being the propositus in whom hæmoglobin *G* was first found, and a number of extramarital offspring.

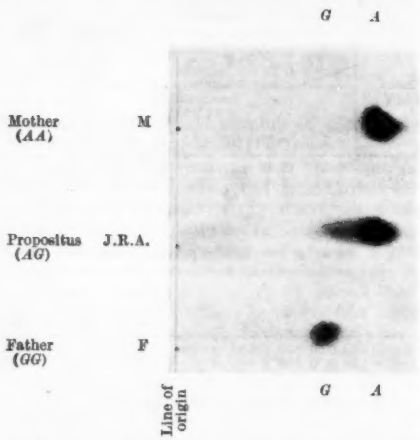

Fig. 1. Comparison of the hæmoglobin of the propositus J.R.A. (*AG*) with that of his father (*GG*) and his mother (*AA*). The cells were frozen after washing and packing. They were then lysed with water and the stroma was removed by shaking with toluene and centrifuging. The hæmoglobin solutions were examined by filter paper electrophoresis at *p*H 8·6. The technique followed was that of Smith and Conley (ref. 7). It will be seen that both parents are homozygotes, for *A* and *G* respectively

Of the ten living presumed full siblings of the propositus, nine were found to have hæmoglobin *G* (*AG*); but one was found to have the sickle-cell trait (*AS*). A family tree was obtained which ought to lead to the identification of further hæmoglobin *G* carriers.

The homozygote for *G* was not anæmic (hæmoglobin 13·9 gm./100 ml. blood), and there was no abnormality noticed in the red cell smear. There were 2 per cent reticulocytes and the serum bilirubin-level was within normal limits. It was not possible to detect fœtal hæmoglobin, which is found almost invariably in homozygotes for *S*, and in a proportion of homozygotes for *C*.

Pure hæmoglobin G. It was of interest to examine the blood of the father more closely. There was no

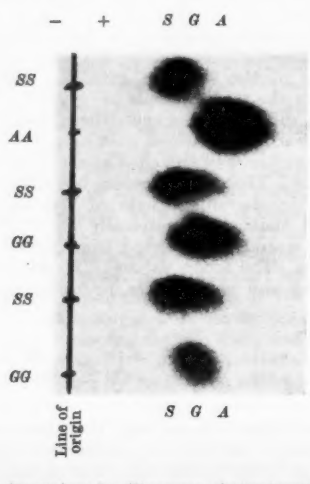

Fig. 2. Comparison by filter-paper electrophoresis at *p*H 8·6 (ref. 7) of hæmoglobins *A*, *G* and *S* prepared from the blood of homozygotes. It will be seen that *G* migrates faster than *S* and more slowly than *A*

Fig. 3. (*a*) Isomorph birefringent crystal of pure hæmoglobin *G* (× 90). (*b*) Rhomboid non-birefringent crystal of hæmoglobin *AG* (× 60)

fœtal hæmoglobin present, and on paper electrophoresis the sample migrated as a single spot (Fig. 2). A spectroscopic examination was performed with the help of Mr. J. M. Campbell on a Unicam spectrophotometer lent by Sir Ernest Kennaway for the purpose. The hæmoglobin from the mother of the propositus (*AA*) was compared with that of the father of the propositus (*GG*). No differences were found in the position of peaks of extinction of reduced *A* and *G*. For oxyhæmoglobin all peaks were identical with one exception; normal hæmoglobin showed one at 4130 A. and the homozygous *G* showed a corresponding one at 4140 A. This difference was presumably due to small amounts of methæmoglobin present in both samples but at different concentrations. A number of derivatives of pure hæmoglobin *G* were also examined at the Medical Research Council Spectrographic Research Unit by Dr. J. C. White and Dr. G. H. Beaven. They found no differences between *G* and *A*.

Solubility. The solubility of hæmoglobin *G* tested by the method of Itano[6] is considerably higher than that of hæmoglobin *S* (> 5 gm. ferrohæmoglobin/litre, 2·24 *M* phosphate buffer); but seems to be either lower than that of hæmoglobin *A* or within the lower part of the range of that hæmoglobin (0·6 gm. ferrohæmoglobin/litre, 2·58 *M* phosphate buffer).

Crystals. Hæmoglobin *G* and hæmoglobin consisting of a mixture of *A* and *G* have both been obtained in crystalline form. The procedure was to prepare solutions of 5 gm. ferrohæmoglobin/litre in 2·24 *M* phosphate buffer as in the solubility test described by Itano[6]. At 25° C. the hæmoglobin was fully soluble; but when the solution was allowed to remain for 24 hr. at 20° C., crystallization occurred readily (Fig. 3). It is hoped to examine these crystals further.

Hæmoglobin *G* has thus now been compared by paper electrophoresis at *p*H 8·6 with all known variants of human hæmoglobin and has been found to differ from them all. It seems to be inherited according to simple Mendelian principles, and a homozygote for *G* has been discovered.

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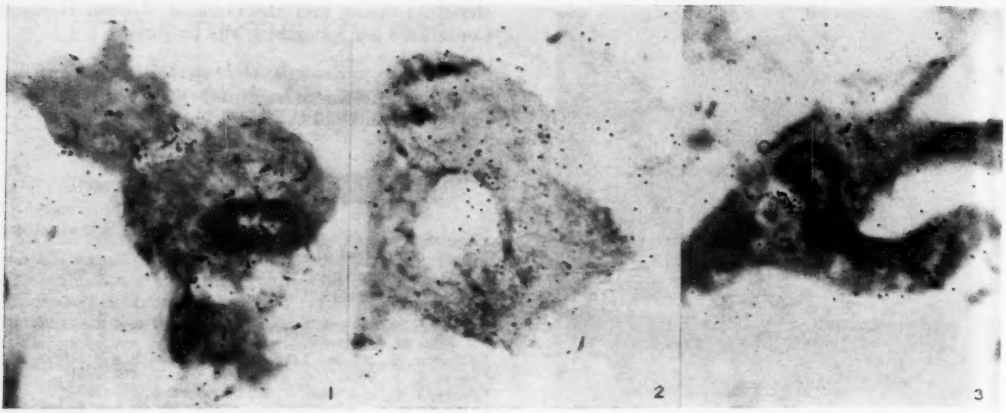
Action of Ribonuclease and Ribonucleic Acid on Living Amœbæ

It has been shown[1] that ribonuclease strongly inhibits the incorporation of labelled amino-acids into the proteins of living onion root-tip cells. In order to extend these findings to animal organisms, the effects of ribonuclease and ribonucleic acid on living amœbæ (*Amoeba proteus*) have been studied.

Crystallized ribonuclease (G.B.I., 0·1 mgm./ml.) quickly inhibits the locomotion of amœbæ. After 90 min. they become almost spherical and, if left longer, they progressively cytolyse. If, after treatment with ribonuclease for 90 min., however, the amœbæ are returned to normal Chalkley's medium, they survive for many hours and attach themselves to the bottom of the dish; but most of them retain their spherical shape. If, on the other hand, they are transferred to Chalkley's solution containing 1·4 mgm. yeast ribonucleic acid (Schwarz, purified on column and neutralized) per ml., a variable proportion (10–40 per cent) of the amœbæ shows normal appearance and locomotion after a few hours. When ribonucleic acid (1·4 mgm./ml.) is present together with ribonuclease (0·1 mgm./ml.) in the medium, the amœbæ are remarkably protected: even after 18 hr. treatment they still stick to the bottom of the dish and appear healthy except for a strong retraction of the pseudopodia. Ribonucleic acid alone produces only a slight retraction of the pseudopodia. The enzymatically inactive oxidized ribonuclease has no, or little, effect on shape and locomotion.

Cytochemical observations with methyl green–pyronine staining show that the ribonuclease treatment produces a considerable loss of basiphily, both in the cytoplasm and the nucleoli; therefore the enzyme must penetrate quickly into the cell and its nucleus, which presents a swollen appearance (this penetration has been confirmed with radioactive ribonuclease and an autoradiographic method). When the amœbæ, after the ribonuclease treatment, are placed in normal medium for 18 hr., the cytoplasm is almost colourless, but the nucleoli often stain well with pyronin; it appears that resynthesis of ribonucleic acid, at the expense of free nucleotides, occurs



Track-autoradiographs of amœbæ incubated in radioactive phenylalanine. (1) Control; (2) after treatment for 90 min. with ribonuclease; and (3) recovery in ribonucleic acid (18 hr.) after ribonuclease treatment

earlier in the nucleus than in the cytoplasm (cf. ref. 2). Most of the amœbæ which, after ribonuclease treatment, have been placed in 1·4 mgm./ml. ribonucleic acid for 18 hr., show the same aspect; but 10–40 per cent of them now look normal in every respect. A mixture of all four nucleotides of yeast nucleic acid seems less effective than the nucleic acid itself in promoting this recovery. The ribonuclease–ribonucleic acid mixture which, as mentioned earlier, exerts no lethal action on the amœbæ, nevertheless produces a very distinct drop in basiphily; the nuclei, however, remain practically normal. Treatment for 18 hr. with ribonucleic acid alone frequently induces an increase in the staining of the nucleoli.

A few experiments on amœbæ which had been cut into nucleated and non-nucleated halves indicate that both halves lose their basiphily after the ribonuclease treatment; but recovery, on addition of ribonucleic acid, only occurs in the nucleated halves.

Quantitative estimation of the ribonucleic acid content in amœbæ treated with ribonuclease (method of Linet and Brachet[3]) shows that after 90 min. it is reduced by 20–45 per cent; simultaneously, the free nucleotide content increases by 50–130 per cent. Amœbæ treated with ribonuclease, when placed in plain Chalkley's solution, usually show, after 18 hr., a further drop in the ribonucleic acid content; but when the amœbæ are put in 1·4 mgm./ml. ribonucleic acid, an almost normal ribonucleic acid content is found in those amœbæ which have normal locomotion.

The next step was to study the incorporation of labelled ^{14}C-phenylalanine in the various types of amœbæ. Measurements with the Geiger–Müller counter showed only 30–45 per cent inhibition after treatment for the usual 90 min. with ribonuclease. But track-autoradiographs, kindly prepared by Dr. A. Ficq, showed that much of the radioactivity comes from radioactive contaminants outside the amœbæ. As shown in Figs. 1 and 2, amœbæ treated with ribonuclease (which have lost a large proportion of their basiphily) incorporate very little of the labelled amino-acid (inhibition 80–90 per cent). In amœbæ which, after the action of ribonuclease, have been placed in the 1·4 mgm./ml. ribonucleic acid medium, three classes of amœbæ can be found by autoradiography: (1) non-basiphilic amœbæ, which incorporate little of the labelled phenylalanine (inhibition 80–90 per cent); (2) basiphilic amœbæ which, however, do not incorporate the amino-acid (inhibition 80–90 per cent); (3) basiphilic amœbæ which incorporate labelled phenylalanine to an almost normal extent (inhibition 7 per cent; Fig. 3). These results suggest that the amœbæ, after ribonuclease treatment, can utilize yeast ribonucleic acid, but that normal protein metabolism is only possible when this foreign nucleic acid has been converted into normal ribonucleic acid.

Finally, in six different experiments, each using fifty healthy amœbæ, the organisms were cultivated, after various treatments, in the presence of micro-organisms suitable for feeding. The amœbæ were re-counted every day; the sum total for all the experiments, after four to six days, is given in Table 1 (the general trend was the same in all six experiments).

Table 1. Number of Amœbæ after Four to Six Days. Initial Number: 300

Control	Ribonuclease (0·1 mgm./ml.) 90 min. + Chalkley 18 hr.	Ribonuclease (0·1 mgm./ml.) 90 min. + ribonucleic acid (1·4 mgm./ml.) 18 hr.	Ribonucleic acid (1·4 mgm./ml.) 18 hr.
456 (+52%)	252 (−16%)	352 (+17%)	528 (+76%)

These experiments show that amœbæ treated with ribonuclease are unable to multiply, although they are capable of feeding, as shown by cytological observations. Addition of ribonucleic acid, after the ribonuclease treatment, tends to restore the capacity to multiply in some amœbæ. Cytological observation, at the end of the culture experiments, shows that some of the amœbæ are perfectly normal, whereas others still retain a low basiphily. Furthermore, ribonucleic acid alone seems to exert a favourable effect on the multiplication of the amœbæ.

A few culture experiments have also been carried out with amœbæ treated with the ribonuclease-ribonucleic acid mixture: they show almost normal capacity for multiplication, except for an initial lag.

It can be concluded that, in amœbæ, it is possible to modify almost at will the ribonucleic acid content of the organism within large limits: incorporation of amino-acid into the proteins and capacity to multiply are closely linked to the ribonucleic acid content. Such conclusions are in keeping with the

ideas expressed by Brachet[4] and Caspersson[5] on the role of ribonucleic acid in protein synthesis.

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Synthesis of Indole and Anthranilic Acid by Mutants of *Escherichia coli*

The pathway of aromatic synthesis in bacteria has been determined mainly by nutritional studies and the accumulation of intermediates in cultures of mutants blocked at various metabolic steps. The biosynthesis of tryptophan probably involves the conversion of aromatic precursors such as shikimic acid through anthranilic acid and indole[1]:

$$\rightarrow \underset{\text{acid}}{\text{shikimic}} \rightarrow \underset{\text{intermediates}}{\text{unknown}} \rightarrow \underset{\text{acid}}{\text{anthranilic}} \rightarrow \underset{\text{indole} \rightarrow \text{tryptophan}}{}$$

In the course of an investigation of the conversion of anthranilic acid to indole by bacteria, it was found that resting-cell suspensions of certain mutants of *Escherichia coli* would form indole from glucose and ammonium salts.

The mutants used in these experiments (Table 1) were derived from *E. coli* 518 (*A.T.C.C.* 9723) following ultra-violet irradiation and penicillin enrichment[2]. Cell suspensions were used immediately after preparation from cultures grown on a heart infusion agar medium, or on a solid synthetic medium[3] with the appropriate growth factors added.

Mutant 1 required tryptophan for growth, but would not utilize indole. Presumably, therefore, it had a metabolic block between indole and tryptophan. The conditions under which mutant 2 forms indole when incubated in phosphate buffer with glucose and ammonium chloride are shown in Table 2. Indole synthesis by cells grown on the synthetic medium was stimulated (about seven-fold) by a heated extract of *E. coli* cells.

Table 1. Mutant Strains of *E. coli*; Summary of Results

Mutant	Strain No.	Parent strain	Growth factor requirements*	Experiments with resting cells	
				Compound formed from glucose + ammon. chloride	Effect of serine on glucose–ammon. chloride system
1	7–4	518	Tryptophan	Indole	Stimulatory
2	T2–15	7–4	Tryptophan + serine or glycine	Indole	Essential
3	1–5	518	Tryptophan or indole	Anthranilic acid	Stimulatory
4	T3–23	1–5	Tryptophan or indole + serine or glycine	Anthranilic acid	Essential
5	7–8	518	Tryptophan or indole	Unidentified indole derivative	Stimulatory
Wild type	518 (*A.T.C.C.* 9723)		None	No detectable amounts of above compounds formed	

* Supplement needed for growth in minimal medium (ref. 3).

Table 2. Indole Formation: Effect of Serine

Substrate			Indole (mμ mole/mgm. dry wt.) formed by	
Glucose (0·1 *M*)	Ammon. chloride (0·005 *M*)	DL-serine (0·01 *M*)	Mutant 1	Mutant 2
+	–	–	37	44
+	+	–	212	61
+	+	+	280	274

Cells (mutant 1, 0·76; mutant 2, 1·04 mgm. dry wt./ml.) incubated with substrates in phosphate buffer (0·1 *M*, *p*H 7·7) for 3 hr. at 37°. Final volume, 5 ml. Cells grown on heart infusion agar.

Indole was estimated colorimetrically with *p*-dimethylamino-benzaldehyde by a modification of the method described by Wood, Gunsalus and Umbreit[4]. Spectrophotometric examination of the experimental samples confirmed the identity of the indole (Fig. 1).

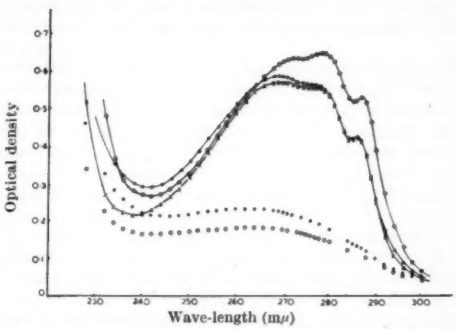

Fig. 1. Absorption spectra of compounds formed by mutants 1 and 5.
—×—×—, Synthetic indole in phosphate buffer (0·1 *M*, *p*H 7·7); —●—●—, experimental sample containing indole formed from glucose and ammonium chloride by mutant 1 in phosphate buffer; —o—c—, experimental sample containing unidentified compound formed by mutant 5. Unjoined circles show control samples from cells in phosphate buffer incubated with glucose only (●● = mutant 1; oo = mutant 5)

Various amino-acids added to the basal glucose–ammonium chloride system either inhibited indole synthesis or had no effect, with the exception of DL-serine, which stimulated the synthesis to a variable extent (15–50 per cent) (Table 2).

To assess the importance of serine in indole synthesis, a further mutant[3] was isolated from mutant 1. Mutant 2 required tryptophan and either serine or glycine for growth (Table 1). Washed cell suspensions of mutant 2 formed indole in the glucose – ammonium chloride system only when serine (or one of the related amino-acids, glycine, threonine or homoserine) was added. Furthermore, if mutant 2 was grown on a solid synthetic medium containing serine, only serine was effective in promoting formation of indole.

There was a lag before the maximum rate of synthesis of indole was attained. Cells of mutant 2 were allowed to become adapted, washed in buffer, and incubated with fresh substrates; there was then no lag in indole formation, but serine was still required. Thus serine is needed in indole synthesis for some reaction other than the formation of adaptive enzyme.

Mutant 3 (Table 1) required either indole or tryptophan for growth. Suspensions of this strain, when incubated with glucose and ammonium chloride under the conditions stated for indole synthesis, formed anthranilic acid (detected by fluorescence and absorption spectrum) at approximately the same rate as indole was formed by mutant 1. As with

indole, the addition of serine to the glucose–ammonium chloride system increased the amount of product formed. Mutant 4, requiring serine or glycine superimposed on the original requirements of mutant 3, was isolated (Table 1). Experiments with suspensions of mutant 4 indicated that serine was required for the formation of anthranilic acid.

Yet another mutant (No. 5) (Table 1) having the same nutritional requirements as mutant 3 was examined. Mutant 5 might have been expected to form anthranilic acid from glucose and ammonium chloride; but instead it formed an unidentified compound with an absorption spectrum (peaks at 278 and 287 mμ) typical of an indole derivative (Fig. 1). This compound differed from indole in ether solubility and by giving only a faint colour with *p*-dimethylaminobenzaldehyde. Serine stimulated the formation of this compound, and its significance in tryptophan synthesis is at present under investigation.

The main experimental findings are summarized in Table 1. It would appear that serine is a substrate for some reaction in the biosynthesis of indole. The actual stage or stages at which serine enters the reaction sequence is not yet known, but it seems that it is required for the synthesis of anthranilic acid.

We wish to thank the National Health and Medical Research Council for partial assistance and Prof. S. D. Rubbo for his encouragement. Strains 7–4 and 7–8 of *E. coli* were isolated by Mr. T. Holdaway during class experiments at the Biochemistry Department, Oxford.

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Specific Differences in the Nucleic Acids from *A* and *B* Strains of Influenza Virus

It has recently been found that influenza virus *A*, strain *PR*8, contains only ribonucleic acid, no appreciable amount of deoxyribonucleic acid being present. The amount associated with the virus is rather small, however, preparations of high infectivity ($LD50/HA > 6 \cdot 0$) containing between 0·8 and 1·0 per cent[1,2]. Although preparations of low infectivity ($LD50/HA \sim 3 \cdot 2$–$4 \cdot 5$) were found to have significantly lower ribonucleic acid contents[2], the possibility still remained that the nucleic acid was not an integral part of the virus particle. A further method of investigating this possibility was to determine the overall ratios of the nucleic acid bases from different strains of influenza virus to see whether any relationship existed between the values obtained and any biological property, for example, serology. The preliminary results of such an investigation are reported here.

Six strains of virus were chosen—four *A* strains (*PR*8, *MEL*, *WSE*, *SWINE*) and two *B* strains (*LEE*, *MIL*). All strains were propagated in the allantoic cavity of 11-day old chick embryos, the allantoic fluid being harvested 30–42 hr. after inoculation of dilute seed virus. The viruses were purified by adsorption to, and elution from, human red cells, followed by two cycles of differential centrifugation[1]. The purity of the preparations was checked by examination in the analytical ultracentrifuge (kindly carried out by Mr. H. F. Holden) and by estimation of the number of hæmagglutinin units per mgm. dry weight.

The nucleic acid was extracted from the defatted virus with hot 10 per cent sodium chloride solution, precipitated from the extract with two volumes of ethanol, washed, dried and digested with 1 *N* hydrochloric acid at 100° C. for 1 hr. The components were separated by paper chromatography in an *iso*propanol – hydrochloric acid medium[3] and estimated in an ultra-violet spectrophotometer[4]. In Table 1 are listed the proportion of the bases (referred to adenine) from the viruses, together with values of a ribonucleic acid sample isolated from an allantoic membrane homogenate (nucleotides separated by paper electrophoresis[5]) and values[6] for the deoxyribonucleic acid isolated from a chick embryo homogenate.

A comparison of the virus preparations shows that the ratios of adenine + uracil to guanine + cytosine yield values which, even in the limited series of experiments presented, show a significant difference between the *A* and *B* strains. The values within the two categories are closely similar. This, then, constitutes perhaps the most definite evidence yet put forward that the ribonucleic acid is an integral part of the influenza virus particle.

Of additional interest is a comparison of the virus values with those of the allantoic membrane ribonucleic acid (mainly cytoplasmic in origin) and the chick embryo deoxyribonucleic acid. Elson and Chargaff have stated that guanine and cytosine predominate in all ribonucleic acid samples (except yeast) studied in their laboratory, whereas adenine and thymine are the major components in most deoxyribonucleic acids[7]. In this respect, the virus nucleic acids show a marked difference, the ratios being in close agreement with the chick embryo deoxyribonucleic acid (thymine replacing uracil) but completely different from the membrane ribonucleic

Table 1. Proportions of Bases in the Nucleic Acids of *A* and *B* Strains of Influenza Virus

Preparation	No. of experiments	Ratios of bases referred to adenine				(Adenine + uracil (thymine)) / (Guanine + cytosine)
		Adenine	Guanine	Cytosine	Uracil (thymine)	
LEE (*B*)	4	10	8·0 ± 0·1	10·0 ± 0·3	15·5 ± 0·5	1·42 ± 0·04
MIL (*B*)	3	10	7·7 ± 0·2	10·4 ± 0·3	15·8 ± 0·2	1·43 ± 0·05
*PR*8 (*A*)	5	10	8·7 ± 0·2	10·4 ± 0·5	14·2 ± 0·13	1·27 ± 0·02
MEL (*A*)	2	10	8·3, 8·8	10·7, 11·3	13·3, 14·5	1·22 ± 0·01
WSE (*A*)	2	10	8·9, 8·9	10·8, 10·5	15·0, 14·3	1·26 ± 0·01
SWINE (*A*)	2	10	9·1, 8·8	10·9, 10·6	14·1, 14·5	1·24 ± 0·04
All membrane ribonucleic acid	1	10	16·6	14·0	10·3	0·67
Chick embryo deoxyribonucleic acid (ref. 5)		10	8·2	7·0	9·1	1·26

acid. Similar high ratios also characterize many of the plant virus nucleic acids studied[7].

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Isolation of Kynurenine and 3-Hydroxykynurenine from Human Pathological Urine

In 1951, 3-hydroxyanthranilic acid was isolated from the urine of a patient with pulmonary tuberculosis after administration of l-tryptophan[1]. This result caused us to examine the urine of various subjects, including some tuberculous patients not receiving special diet or supplementary administration of tryptophan. By means of paper chromatography it was found that the urine of normal humans contains very small quantities of 3-hydroxyanthranilic acid, while in eleven out of thirteen patients affected with pulmonary tuberculosis, excretion was definitely higher[1].

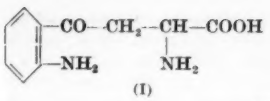
In a case of severe tuberculosis with a positive diazo reaction in the urine, Makino *et al.*[2] identified 3-hydroxykynurenine by paper chromatography, chromatic reactions and adsorption spectrum. More recently, Dalgliesh and Tekman[3] found that in a large proportion of cases febrile humans excrete 3-hydroxykynurenine, and this excretion is, in particular, unrelated to tuberculosis or diabetes. It is attributed to a high rate of breakdown of body protein. We have been working for the past two years on the excretion of kynurenine and 3-hydroxykynurenine in pathological human urines. Preliminary results have been reported[4]. We can now report on the investigations as a whole.

So far, we have examined chromatographically the urine of 321 subjects: 32 normal persons, with normal feeding, ages 20–72, the remaining 289 in the various clinics of Padua (pulmonary tuberculous patients excluded) and given ordinary hospital diets.

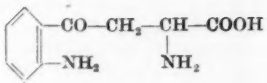
The urine of normal humans, used as control, gave results that were negative. The urine of several patients was also negative; in many others a slight excretion of metabolites was noted, mainly kynurenic and xanthurenic acids, anthranilic and 3-hydroxyanthranilic acids and, sometimes, kynurenine and 3-hydroxykynurenine. Very often the result was not constant: it varied from day to day and, in every case, excretion was slight. Among these cases were twenty patients suffering from different forms of neoplastic diseases (cancer of skin, uterus, intestine, etc.). In six of these we found excretion of both kynurenines; in seven, kynurenine alone; and no metabolite in the others. This problem will be the subject of further researches.

We found a positive result in hæmoblastotic forms, as reported in Table 1.

Seventy-six cases were examined. In fifty-nine, kynurenine (I) and 3-hydroxykynurenine (II) (both free and conjugated) were found in considerable quantities,



(I)



(II)

besides small quantities of kynurenic and xanthurenic acids; in eleven cases kynurenine was present, but 3-hydroxykynurenine was absent. On the other hand, in six subjects, some of uncertain diagnosis, the kynurenines are absent; among these were also four patients treated with a colchicin derivative that we consider as probably inhibiting the excretion of the tryptophan metabolites.

All seventy-six patients have been followed from a minimum of three to a maximum of 120 days by means of chromatographic analysis. We have been able to confirm an important daily excretion of the kynurenines. The variations of body temperature, before and during the period in which the urine samples were taken, were noted from the clinical charts. From the cases examined it was observed that the excretion takes place during both normal and fever periods; it was also seen that the recession of the fever does not provoke the arrest of this excretion. The investigation was completed with the isolation of kynurenine and 3-hydroxykynurenine in the pure form.

We chose four cases from the Medical Clinic of the University of Padua: (1) chronic myeloid leukæmia; (2) and (3) Hodgkin's disease; (4) lymphoid leukæmia. Case (1): from nine litres of urine, 40 mgm. of kynurenine sulphate and 16·4 mgm. of 3-hydroxykynurenine were obtained. Case (2), 5·5 litres of urine gave 34 mgm. of kynurenine sulphate and 21·1 mgm. of 3-hydroxykynurenine. Case (3) (Hodgkin's disease with normal body temperature), 7·1 litres of urine gave 23·8 mgm. of kynurenine sulphate and 9 mgm. of 3-hydroxykynurenine. Case (4), 24·1 litres of urine gave 68·5 mgm. of kynurenine sulphate; 3-hydroxykynurenine was also present, but the amount was not sufficient to permit isolation. Analyses, ultra-violet spectra and chromatic reactions of compounds isolated agree completely with those described in the literature. Full results will be published elsewhere.

The quantities of the two substances originally present in the urine, calculated approximately by means of the ninhydrin colour method, were much higher than those actually isolated.

Table 1

Diagnosis	No. of cases excreting			Total
	kynurenine and 3-hydroxy-kynurenine	kynurenine alone	not excreting	
Myeloid leukæmia	22	5	4	31
Lymphoid leukæmia	19	5	2	26
Hodgkin's disease	14			14
Hæmocytoblastic leukæmia	1			1
Histiocytic leukæmia	1			1
Lymphosarcoma	1			1
Multiple myeloma	1	1		2
Total	59	11	6	76

In earlier work by other authors on leukæmic urine, the only substance found was indirubin. Thus[5], injecting extracts obtained from the urine of leukæmics into guinea pigs, it was possible to produce qualitative histological alterations similar to those characteristic of leukæmia. Other authors have repeated this experiment; but no definite results have as yet been achieved. It appears that leukæmic urine contains three times as much indirubin as normal urine[6]. It should be pointed out that indirubin has also been extracted from the urine of pregnant mares and, by one of us[7], from the urine of rats and rabbits previously fed with fibrin.

An unknown substance that reacts with ninhydrin and which is occasionally present in various urines appears to have been found in leukæmics in higher concentrations[7]. Furthermore, Japanese scientists[8] have reported that the urine of leukæmic patients reveals, by means of paper chromatography, the presence not only of known amino-acids but also of an unknown compound that is coloured by ninhydrin; this compound was found in twenty-seven out of twenty-nine patients and in four out of seventeen normal persons.

It is not easy, however, to correlate these observations with our findings concerning the isolation of the kynurenines. We would emphasize, however, that, hitherto, the extraction of tryptophan metabolites has been rare without the use of special diets or administration of tryptophan. It seems that in the human such excretion is linked with pathological conditions.

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Cobalt Chloride and the Alpha-Cells of the Pancreas

The hyperglycæmic glycogenolytic factor found in the pancreas of normal and of alloxan-diabetic animals was assumed to be the product of the α-cells of the Langerhans islets[1]. When administered parenterally, simple cobaltous salts damage selectively the α-cells[2], and were therefore considered useful for investigating whether the hyperglycæmic factor meets the criteria of a hormone. Since administration of cobaltous salts also elicits a transitory hyperglycæmia[2,3], it has been suggested that they initially excite the α-cells, and then cause them to degenerate[2]. This hypothesis is invalidated by the facts that animals treated with cobalt chloride do not become hypoglycæmic and that repeated injections evoke transitory hyperglycæmic responses even after the α-cells are no longer demonstrable histologically[3]. Also, more of the hyperglycæmic factor could be extracted from the pancreas after such destruction of α-cells than from normal controls[4]. Ellis *et al.*[5] found that dihydroergotamine inhibits hyperglycæmia caused by cobalt chloride, but not the effect of the hyperglycæmic factor.

While investigating the biological activity of a number of inorganic complexes[6], it was found that some of them caused glycosuria in experimental animals. The blood-glucose level after the intraperitoneal injection of 120–150 μgm. per gm. bodyweight of *dl*-tris-ethylenediamine cobalt III chloride $[Co(en)_3Cl_3]$ to starved albino rats showed the following characteristics; the blood glucose started to rise 15 min. after injection, reached its peak between 30 and 120 min., and returned gradually to normal within 4–4½ hr. without sinking below the initial level. The initial dose repeated three hours later caused a second peak in the blood-glucose curve, though these animals usually succumbed within a few hours to the toxic effect of the complex[6]. Animals which received daily doses of the complex showed unaltered reactions after each injection for a period of eight to fourteen days, after which they died. The height of the blood-glucose level after starvation was not affected by treatment on previous occasions. The rise in blood-sugar values after a single injection ranged from 40 to 200 mgm. per cent and was in no way proportional to the amount of complex administered.

The behaviour of the blood-glucose level after the injection of this complex had a striking similarity to that caused by simple cobaltous salts. Also, the amount of cobalt administered in a dose of cobalt chloride or of $Co(en)_3Cl_3$ which caused a hyperglycæmic reaction was of the same order. However, the relevance of this finding is not at present clear, since its implication that the cobalt ion itself is the hyperglycæmic agent is not tenable for the following reasons. The $Co(en)_3^{3+}$ ion is a co-ordinately saturated and extremely stable complex, with a stability constant[7] of 10^{47}. It has been shown previously that the biological activity of many stable complexes is a function of the cation as a whole and not of the metallic atom[5]. Also, similar complexes containing different metals (see Table 1) showed a hyperglycæmic activity of the same type as the $Co(en)_3^{3+}$ ion.

Table 1. Effect of Cobalt Chloride, Inorganic Metal Complexes and Cobalt Chloride + Amino-Acid Mixtures on Blood-Glucose Level and Pancreatic α-Cells

Compound administered	Route of administration	Behaviour of blood-glucose level	Condition of α-cells
$CoCl_2$	Intraperitoneal or intravenous	Hyperglycæmia	Absent
$Co(en)_3Cl_3$	,,	,,	Normal
$Co(NH_3)_4Cl_2$	,,	,,	,,
Tris-glycine CoIII	Intraperitoneal	,,	,,
$Rh(en)_3I_3$	,,	,,	,,
$Os(en)_3Cl_2$	,,	,,	,,
$CoCl_2$ + *dl*-methionine	Intraperitoneal or intravenous	,,	,,
,, ,, + *l*(+) histidine HCl	,,	,,	,,
,, ,, + *dl*-alanine	Intraperitoneal	,,	Not determined
,, ,, + *l*(+) arginine HCl	,,		,,
,, ,, + *dl*-leucine	,,		,,

The hyperglycæmic responses to the above compounds show the same individual variations as to the ethylenediamine–cobalt ion and cobalt chloride. The pancreatic sections were stained by Gomori's method (ref. 8).

Histological sections prepared from the pancreas of rats and rabbits which received either single injections of, or prolonged treatments with, the complexes revealed that none of them caused any recognizable damage to the α-cells of the islets of Langerhans.

It was found that the complex of trivalent cobalt with glycine caused hyperglycæmia. Since the cobaltous ion would readily form complexes with the free amino-acids of the serum, it was considered of interest to test whether complexes of cobaltous ions and amino-acids also showed a similar activity. The solutions of amino-acids (see Table 1) were neutralized and mixed with cobalt chloride. These mixtures, which contained cobalt chloride and amino-acid in the ratio of 1 : 3 (in a few instances 1 : 6), were given intravenously to rabbits. Histological sections were prepared from the pancreas of rabbits which received cobalt chloride plus methionine, and cobalt chloride plus histidine. Although the mixtures exhibited the same hyperglycæmic activity, none of the sections examined showed any damage to the α-cells of the pancreas.

These results suggest that the hyperglycæmic action of cobalt chloride and its effect on α-cells of the pancreas are two independent phenomena. The mechanism of the hyperglycæmic action of the complexes and cobalt chloride is being further investigated.

I am indebted to Drs. E. C. Gyarfas and F. P. Dwyer for the preparation and supply of inorganic complexes used in this work.

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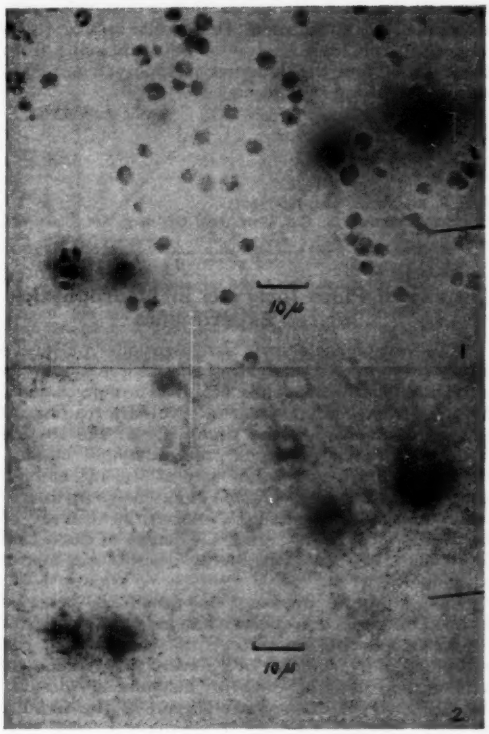
High-resolution Autoradiography of Water-soluble Substances

The stripping-film technique of Pelc[1] for the autoradiography of radioactive substances incorporated in microscopic sections requires that the film should be put on in water. Consequently the method cannot be applied directly to the location in tissues of substances which are soluble in water. Chapman-Andresen[2] has kept such substances from moving by covering the tissue with a thin film of nylon or other material. This technique is suited for the restripping[3] process in which the emulsion is separated from the tissue before development and examined separately, but is less suited to the direct simultaneous examination of the section and radiograph, which avoids the possibility of reorientation and change of scale. Although the resolution obtainable by the stripping-film technique depends very critically on the distance between the tissue and the photographic emulsion, Chapman-Andresen claims that resolution is unaffected by the films used.



(1) *Chlorella* cells viewed through the radiograph film. (2) The same field as (1), a higher focus, showing the autoradiograph

In the course of studies on ion accumulation, I have developed a technique for mounting the stripping film on the tissue section without the necessity of interposing other films, and without allowing water-soluble substances in the section to move. The stripping film is removed from its plate and allowed to swell on water in the usual way. It is removed from the water, rinsed in dry chloroform, and arranged on the slide bearing the tissue in a fresh bath of dry chloroform, emulsion side down. The film is then dried rapidly in absolute alcohol, followed by a draught of cool air. After exposure, the film is examined microscopically through the photographic film. Aggregates of silver grains are visible in the emulsion over those parts of the tissue which contained radioactive substances during exposure. The resolution obtainable with water-soluble substances by this method is as good as that for insoluble substances by the normal method.

The preparation of the tissue section must be made with care to preserve the position of the water-soluble substances. Each tissue to be examined presents its own problem. The cells, radiographs of which are shown (Figs. 1 and 2), were prepared by freeze drying and injecting straight from the vacuum with dry chloroform. No sectioning was necessary.

By this technique a feature of accumulation by unicellular organisms has been revealed. Cells of *Chlorella pyrenoidosa* were grown in the light for thirty minutes in a medium containing strontium-90

ions. The radiograph shows that a few cells only have taken up strontium. These cells appear to be dividing. The high energy of beta-emissions from strontium-90 and the daughter isotope yttrium-90 is probably limiting resolution.

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Display of Pulse Intervals in Neurophysiological Experiments

In electrophysiological investigations of nerve impulse activity, an analysis of the intervals between individual potentials is often useful. The conventional method of determining such intervals by reading off each of them against the time-scale of the tracing is, however, a very tedious procedure and, besides, the cost of film run continuously at the rather high speed required is not negligible in extensive investigations. Methods permitting a more direct survey of the results, preferably during the course of the actual experiment, are therefore highly desirable in neurophysiological work.

When studying processes in which the interval between successive impulses changes only slowly, at a more or less constant rate, satisfactory results can be obtained by the use of counting-rate meters of conventional design. Such an instrument[1], directly indicating the frequency per second of the impulse discharge studied, coupled to an ink-writer for continuous recording of the frequency variations, has proved to be of great value for the exploration of the discharge patterns of single units of the central nervous system[2]. However, a rate meter of this type, based on an integrating network exhibiting a time constant, is not able to follow rapid variations in pulse intervals, and a complementary method has therefore been developed which permits an easy survey of the spacing of the individual nerve impulses. Although the apparatus has certain limitations in comparison with the elaborate pulse-interval meter recently described by Andrew and Roberts[3], it has the advantage of being simple, as appears from the block diagram Fig. 1.

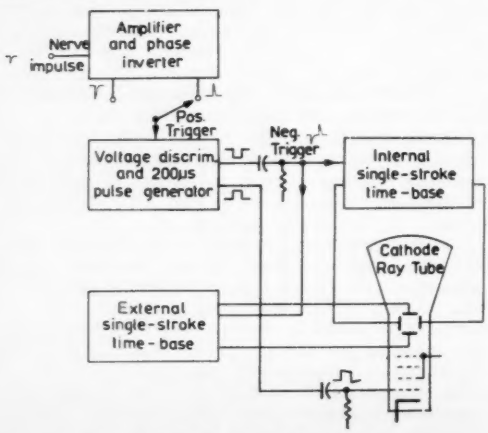

Fig. 1. Block diagram of display unit

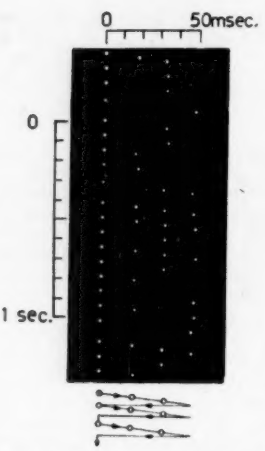

Fig. 2. Recorded impulse pattern from a proprioceptive nerve fibre. The first impulse is that in the top left-hand corner. The sequence is indicated by the arrows below showing the movement of the cathode ray. The vertical separation of successive horizontal sweeps is not constant but depends on variations in the impulse patterns (see text)

The oscillograph is provided with facilities for brightness modulation and for single-stroke sweep operation along the X-axis. A slow external, single-stroke, sweep circuit is connected to the Y-plates. The intensity control of the oscillograph is set low so as to suppress the spot. The train of nerve impulses to be investigated is passed through an amplitude discriminator producing one square wave pulse of a few hundred microseconds duration for each incoming impulse exceeding a pre-set amplitude. The first pulse in the train triggers both the horizontal and vertical time-base, and each pulse modulates the intensity of the cathode ray, thereby producing a series of bright spots on the screen. When the first horizontal sweep is completed, the cathode ray moves rapidly back to the left and is ready to be triggered by a following pulse. Due to the continuous slow vertical sweep movement, a pattern of spots appears on the screen, the distance between successive spots along a single horizontal sweep being a measure of the impulse intervals. By varying the speed of the horizontal sweep, a suitable number of impulses can be made to appear on each sweep. The termination of the slow vertical sweep completes one operation of sampling a train of nerve impulses. It will be noted that one interval is lost between successive horizontal sweeps; this is, however, insignificant for many types of analysis, since a simultaneous check on the average frequency is obtained by the use of a counting-rate meter.

A cathode-ray tube with a long-persistence screen allows of a rapid survey of the intervals during the actual experiment. As the start of each horizontal sweep is always synchronized with the arrival of a nerve impulse, a mere glance at the configuration of the spots on the screen is sufficient to reveal pertinent facts concerning the interval variations. Thus, for example, a pattern in which the spots tend to be grouped in vertical rows indicates similar intervals or multiples of these intervals, as illustrated in Fig. 2, whereas a progressive change in intervals is shown up by oblique rows; on the other hand, random spacing of the nerve impulses is indicated by the absence of any such regular pattern.

The simplest way of recording the pattern is to photograph the horizontal sweeps on a vertically moving film running continuously at slow speed, with the external (vertical) time-base circuit disconnected.

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A Sensitive Method for the Estimation of Hydrogen Peroxide in Biological Materials

During recent years a number of methods for the estimation of hydrogen peroxide which utilize the principle of coupled oxidation have been published. Catalase or peroxidase combines with hydrogen peroxide as it is liberated, and the complex thus formed then brings about the oxidation of such substances as nitrite[1], ethanol[2], cytochrome *c*[3], or manganous ions in presence of *p*-cresol[4]. The extent of these oxidations may be measured by manometric, colorimetric or spectrophotometric means. The method of detecting hydrogen peroxide to be described is based on the same principle but has the advantage of greater sensitivity. In this case the disappearance of the fluorescent peroxidase substrate scopoletin (6-methyl-7-hydroxy-1 : 2-benzopyrone) is observed with the aid of a suitable fluorometer. The Beckman spectrophotometer model *DU* used as for the estimation of fluorescence in solution (Beckman Bull. 149-*G*) was found satisfactory, a concentration of 2×10^{-10} mole per ml. giving a reading of 100 divisions on the intensity scale with the instrument adjusted to its highest sensitivity. Up to $2{\cdot}5 \times 10^{-9}$ mole per ml., the intensity of fluorescence is proportional to the concentration of scopoletin (Fig. 1).

An aqueous solution of scopoletin is reasonably stable in diffused light and is not oxidized by either peroxidase or hydrogen peroxide alone. However, if peroxidase and hydrogen peroxide are both added, oxidation with loss of fluorescence proceeds very rapidly. Fig. 2 shows the quantitative relationship between the amount of hydrogen peroxide added and disappearance of scopoletin. In this experiment each reaction mixture was made up to 1 ml. and contained an aqueous extract of commercial dehydrated horse radish at *p*H 4·5, $2{\cdot}5 \times 10^{-8}$ mole of scopoletin and varying amounts of hydrogen peroxide. After a few minutes, 9·0 ml. of borate buffer (*p*H 10) was added and the residual scopoletin fluorescence measured. Precisely one mole of hydrogen peroxide was required for the oxidation of one mole of scopoletin. This simple stoichiometry applied so long as the scopoletin was present in about 20 per cent excess.

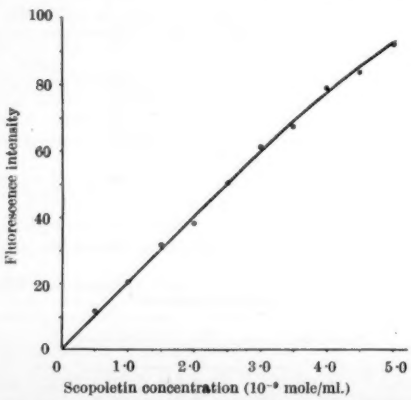

Fig. 1. Fluorescent intensity of scopoletin solutions at concentrations up to 5×10^{-9} mole per ml. in borate buffer *p*H 10

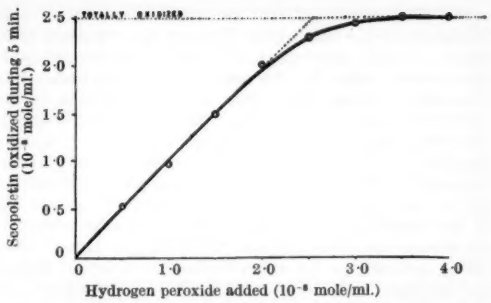

Fig. 2. Relationship between the quantity of hydrogen peroxide and the amount of peroxidative oxidation of scopoletin. Reaction mixtures contain per ml. $2{\cdot}5 \times 10^{-8}$ mole scopoletin, hydrogen peroxide as indicated in the figure and aqueous extracts of dehydrated horse radish at *p*H 4·5

The experiment was repeated using metabolically produced hydrogen peroxide. Pea epicotyl juice contains a diamine oxidase which produces one mole of hydrogen peroxide per mole of putrescine oxidized[4]. It also contains a peroxidase. Fig. 3 illustrates the effect of time on the oxidation of scopoletin by pea epicotyl juice (*p*H 6·8) when enzymatic oxidation of putrescine contributes the necessary hydrogen peroxide. In this experiment $1{\cdot}2 \times 10^{-8}$ mole of putrescine was added to a ten-fold excess of scopoletin. The reaction commenced immediately but proceeded slowly, coming to completion within 11 min. About 80 per cent of the predicted amount of scopoletin was oxidized. On a second addition of $1{\cdot}2 \times 10^{-8}$

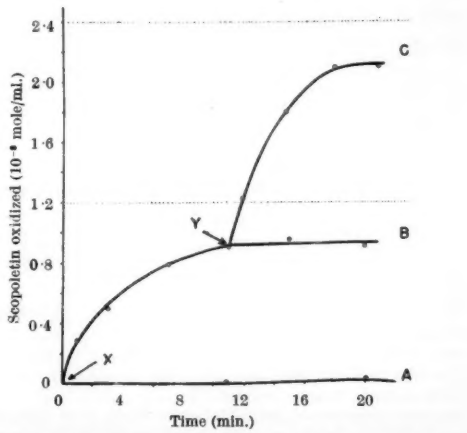

Fig. 3. Rate of oxidation of scopoletin ($1{\cdot}2 \times 10^{-8}$ mole per ml.) by pea juice *p*H 6·8 with putrescine as source of endogenous hydrogen peroxide (curve *A*). Additions: curve *B*, $1{\cdot}2 \times 10^{-8}$ mole putrescine (at *X*); curve *C*, a second addition of $1{\cdot}2 \times 10^{-8}$ mole putrescine 11 min. later (at *Y*)

mole of putrescine, the reaction was faster and oxidation of the theoretical amount of scopoletin took place. When equivalent amounts of hydrogen peroxide were added to the reaction mixture instead of putrescine, it was found that only 66 per cent of the theoretical amount of scopoletin oxidation occurred. Similarly, a second addition of hydrogen peroxide resulted in the theoretical amount of oxidation. Apparently there are present in pea juice alternative peroxidase substrates which may interfere, especially in the more alkaline *p*H ranges. For this reason it sometimes becomes necessary to remove these interfering substances by a preliminary oxidation before proceeding with the quantitative estimation of hydrogen peroxide production.

A number of reducing substances are capable of competitively inhibiting the oxidation of scopoletin by peroxidase; for example, ascorbic acid, glutathione and manganous ions. Consequently other fluorescent phenolic coumarin derivatives were investigated. Esculetin is more readily oxidized by peroxidase than is scopoletin, and ascorbic acid does not interfere, but unfortunately its fluorescence is relatively weak and, moreover, its oxidation by molecular oxygen is catalysed by polyphenol oxidase (scopoletin is not oxidized by polyphenol oxidase over a period of four hours). On the other hand, umbelliferone is resistant to peroxidative oxidation. Scopoletin therefore appears to be the best fluorescent indicator so far found for the peroxidative estimation of hydrogen peroxide. After interfering substances have been removed by a preliminary oxidation, amounts of endogenously produced hydrogen peroxide in the range of 10^{-10} mole can be determined quantitatively. This represents a hundred-fold increase in sensitivity over previous methods. The limitations of available analytical procedures are in large part responsible for the paucity of information of hydrogen peroxide metabolism in plant and animal tissues. This new method incorporates features which make it particularly suitable for biological investigations.

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The Primary Photochemical Process in Bromine

The absorption spectrum of bromine exhibits a continuum which commences at about 5107 A., and it is known that the absorption of light of wavelength less than this value causes the dissociation of bromine into an atom in its normal $^2P_{3/2}$ state and one in the excited $^2P_{1/2}$ state. Photochemical studies have shown that bromine molecules are also dissociated when irradiated with light of wavelengths greater than 5107 A. Thus the quantum yield of the hydrogen–bromine reaction[1] is approximately the same at 5460 A. as for light of wavelength in the continuum, that is, 5107 A. Further, it has been demonstrated that the quantum yield[2,3] for the photobromination of ethylene is independent of wave-length between the limits 4800 and 6800 A.

Two theories have been proposed to explain this constant quantum yield for light with wave-length in the discrete region of the bromine spectrum. Jost[1] suggested that the excited bromine molecules formed by the absorption of radiation with wave-length in the banded region of the spectrum dissociate with high yield into normal ($^2P_{3/2}$) atoms on collision with other molecules. Kistiakowsky and Sternberg[3] have controverted this point of view and instead suggest that the absorption of light at the longer wave-lengths is largely due to bromine molecules possessing some vibrational energy due to thermal excitation. The main evidence in support of this new theory comes from measurements of the temperature variation of the coefficients of absorption of light for bromine. In this communication it is shown that theoretical calculations of the temperature variation of the absorption of light by vibrationally excited bromine molecules yield results in good agreement with the experimental data of Kistiakowsky and Sternberg.

The intensity of absorption of light of frequency ν is given by the formula:

$$I^{v'v''}_{\text{abs.}} = \frac{8\pi^3}{3hc} I_0 \Delta x N_{v''} \nu |R^{v'v''}|^2 \qquad (1)$$

where I_0 is the intensity of the incident radiation, Δx is the thickness of the absorbing layer, $|R^{v'v''}|$ is the matrix element for the transition between the electronic states with vibrational levels v' and v'', and $N_{v''}$ is the number of molecules in the vibrational level v'' of the ground-state. $N_{v''} = N \dfrac{\exp\{-G_0(v'')hc/kT\}}{f}$, where f is the partition function, and $G_0(v'') = \omega_0 v'' - \omega_e x_e v''^2 + \omega_0 y_0 v''^3 \ldots$, $\omega_0 = \omega_e - x_e\omega_e + 3\omega_e y_e/4 \ldots$, and $\omega_e y_0 = \omega_e y_e \ldots$. Since with Kistiakowsky and Sternberg[3] we suppose that the absorption of radiation by the vibrationally excited bromine molecules leads to dissociation, it is easy to see that the ratios of the absorption coefficients at two different temperatures T_1 and T_2, for light of a given frequency, are:

$$I(T_2)/I(T_1) = N_{v''}(T_2)/N_{v''}(T_1) = \exp\{-G_0(v'')hc(T_1 - T_2)/kT_1T_2\} \qquad (2)$$

For the ground $^1\Sigma_g^+$ state of bromine[4], $\omega_e = 323{\cdot}2$ cm.$^{-1}$ and $\omega_e x_e = 1{\cdot}07$ cm.$^{-1}$; $\omega_e y_e$ is unknown but can be neglected. Using these spectroscopic constants, the ratio $I(422{\cdot}1°\text{ K.})/I(308{\cdot}1°\text{ K.})$ has been calculated for bromine molecules excited in various vibrational levels of the ground-state. Table 1 gives the results of these calculations and shows also the values calculated from the experimental data of Kistiakowsky and Sternberg.

The agreement between the two sets of values is particularly good in the case of the $v'' = 3$ level, and the general concordance between the theoretical and the experimental values for these three levels must

Table 1. Absorption Coefficients for Vibrationally Excited Bromine Molecules

v''	$G_0(v'')$ cm.$^{-1}$	$I(422{\cdot}1)/I(308{\cdot}1)$ Calculated	Experimental
1	321·06	1·49	1·11
2	639·98	2·23	1·7
3	956·76	3·32	3·46

be taken as supporting evidence for the Kistiakowsky and Sternberg theory.

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A Relation between Hardness and Stoichiometry in Lead Sulphide Single Crystals

In the course of an investigation concerning the semiconducting properties of lead sulphide, single crystals were prepared and reheated under various sulphur pressures at 1,200° K. in order to control the deviations from the exact stoichiometric composition. The concentration of impurities in these crystals was less than 10^{17} cm.$^{-3}$ (5×10^{-6} atom per mole lead sulphide).

When equilibrium with the ambient gas atmosphere had been reached, the crystals were rapidly cooled to room temperature and the concentration of free-charge carriers was determined by measuring the Hall coefficient.

From these experiments the conclusion was drawn that introduction of excess lead into the crystal on a lattice site causes the formation of a sulphur ion vacancy (anion vacancy, V_A). Of the two electrons given off by the lead atom (when giving a Pb^{2+} ion), the first remains trapped at the positively charged sulphur vacancy and the second one is so weakly bound to the resulting V_A^- centre that at room temperature it behaves as a 'free' electron. Similarly, introduction of extra sulphur atoms gives rise to an equal concentration of lead vacancies that have trapped a hole (V_C^+) and free holes. In Fig. 1 the concentrations of free charge carriers (corresponding to the concentration of cation and anion vacancies) are plotted against the pressure of sulphur vapour in which the crystals had reached their equilibrium.

The hardness of these crystals was measured under a 100-gm. load and is given in the Vickers scale, Fig. 2.

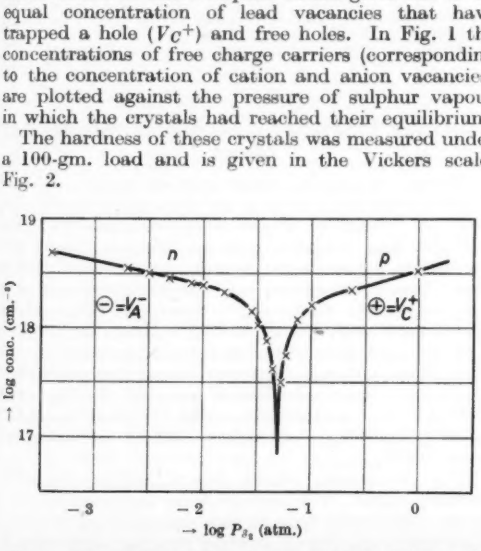

Fig. 1. Concentrations of free electrons and holes (being equal to the concentrations of sulphur vacancies, V_A^-, and lead vacancies, V_C^+, respectively), measured at room temperature on lead sulphide single crystals after reheating under various partial pressures of sulphur (P_{S_2}) at 1,200° K.

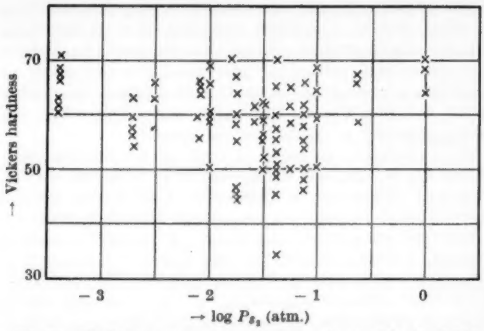

Fig. 2. Hardness, measured on cleavage planes of lead sulphide single crystals after reheating at 1,200° K. under various sulphur pressures

The results show considerable scatter, but it seems justified to conclude that among the stoichiometric crystals (log $P_{S_2} = -1{\cdot}4$ atm.) there are crystals showing a minimum hardness (about 40–50 Vickers); this is not the case for strong n- and p-type crystals, prepared by reheating at lower or higher sulphur pressures.

The results suggest that, although several other factors undoubtedly play a part in increasing the hardness, the concentration of vacancies is of importance, a low concentration being a necessary condition for the observation of a low hardness.

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Solution of Elastic Vibration Problems with the Resistance-Network Analogue

The vibration of an elastic plate is described by the equation:

$$\nabla^4 w = a\nu^2 w \qquad (1)$$

where the symbol ∇^4 stands for the operator $\frac{\partial^4}{\partial x^4} + 2\frac{\partial^4}{\partial x^2 \partial y^2} + \frac{\partial^4}{\partial y^4}$, $w = w(x,y)$ is the displacement, a a constant describing the elastic properties of the plate, and ν the frequency of vibration.

It was shown in a previous communication[1] that the equation:

$$\nabla^4 w = f \qquad (2)$$

where $f = f(x,y)$ is a known function of the coordinates x and y, can be solved by a resistance-network analogue comprising two resistance-networks in cascade. The function f is represented in the analogue by the currents fed in at the 'upper' network of the network cascade, and the function w by the voltages appearing at the mesh nodes of the 'lower' network.

It has also been demonstrated[2,3] that oscillation problems of the form:

$$\nabla^2 \varphi = -\varkappa^2 \varphi \qquad (3)$$

where $\varkappa^2$ is a characteristic value parameter, can be solved by combining the resistance-network technique of solving Laplace- or Poisson-type problems with an iterative method in which the currents fed into the network junctions are cyclically readjusted until

a 'self-consistent' solution, satisfying equation (3) at all mesh nodes, has been established. In practice, four to six iteration cycles are required to reduce the numerical errors of the analogue solution of equation (3) to rather less than the truncation error of the solution due to the finite, and often relatively small, number of mesh points used.

This iterative process of finding a characteristic value can be applied to the solution of equation (1). The only difference is that now it is no longer the current and voltage at the same network junction which are compared and made to satisfy a certain relation to each other, but the current flowing into a network point in the upper network is correlated with the voltage appearing at the corresponding junction of the lower network. This requires modifications of some details of the iteration process previously described[3], but does not introduce any major changes in technique. However, as in solutions of the biharmonic equation, the mixed boundary conditions which can appear in elastic plate problems can present severe difficulties.

Fig. 1 shows, as an illustration of the method by a one-dimensional example, the analogue solution of a vibrating uniform steel rod cantilever of 1 in. diameter and of length $l = 50$ in., the rod being clamped at one end (that is, $w = 0$ and $dw/dx = 0$), and free at the other end ($d^2w/dx^2 = 0$ and $d^3w/dx^3 = 0$). The full line represents the exact solution, and the dotted points the analogue solution. It is seen that the two solutions agree closely. There is a slight difference in the value of the vibration frequency, the analogue solution giving $\nu = 72{\cdot}5$, whereas the exact solution is 71·8. The larger part (0·6 per cent) of this difference of 1 per cent is due to the truncation error, caused by the substitution in the network analogue of the fourth difference for the fourth-order derivative.

The network analogue method has also been applied to the problem of 'whirling shafts', where equation (1) is replaced by:

$$\frac{d^2}{dx^2}\left(EI\,\frac{d^2w}{dx^2}\right) = 4\pi^2 m\nu^2 w \qquad (4)$$

the main difference being that the moment of inertia I and the mass per unit length m are, in a practical problem, both functions of x. Hence, multiplying factors proportional to $m(x)$, which may be different for each network analogue point, have to be used

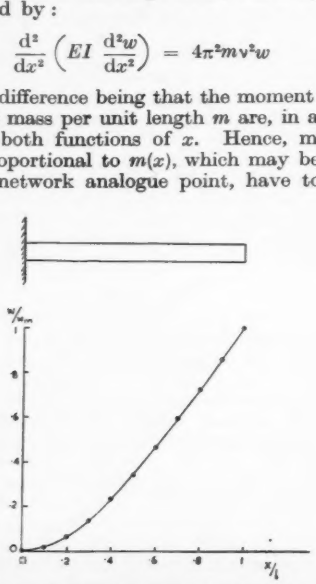

Fig. 1. Vibrating steel bar, 1 in. diameter and 50 in. long. ν exact = 71·8, ν exp. = 72·5. The continuous curve is theoretical; the points on the curve represent measurements made on the resistance network

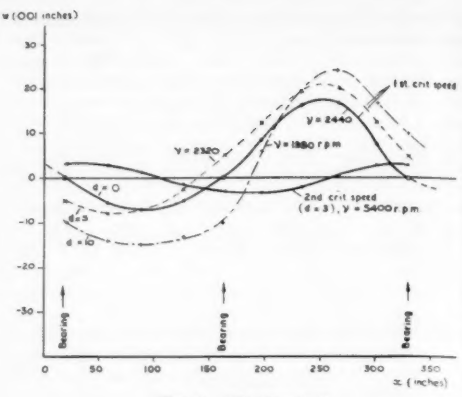

Fig. 2. Whirling shaft

when evaluating the currents to be fed in. Also, the resistances interconnecting the two networks may have different values, as each of these resistances is to be proportional to the value of EI averaged over the corresponding mesh interval. It is also possible to account for prescribed bearing deflexions by presetting the corresponding network voltages at the mesh points representing the bearings. Higher modes of the critical speed can be investigated by introducing additional vibration nodes ($w = 0$) and finding the positions of the additional vibration nodes which equalize the sectional values of ν. Fig. 2 shows a typical set of network analogue solutions for a 'whirling shaft', with uneven mass distribution and three bearings, for several values of bearing deflexion d (in 0·001 in.).

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[1] Liebmann, G., *Nature*, 172, 78 (1953).
[2] Liebmann, G., *Nature*, 164, 149 (1949).
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D-Layer Ionospheric Echoes at Macquarie Island

Many ionosphere investigators have reported echoes observed, presumably at vertical incidence, from an equivalent height of approximately 50 km. Ellyett[1] has described echoes observed from *D*-heights at some Pacific Islands, and considers that these particular echoes may be characteristic of a tropical region. Beagley[2] has observed similar echoes at Christchurch (lat. 43·5° S., long. 172·8° E.). Echoes from *D*-heights have been recorded at the Australian National Antarctic Research Expeditions' Station at Macquarie Island (lat. 54° 30′ S., long. 158° 57′ E; geomag. lat. −61·7°) since the ionospheric recording apparatus began operation in June 1950.

The Macquarie Island echoes, at a minimum virtual height of about 40 km., are identified as being of the same type as those observed at Pitcairn, Christmas and Raoul Islands and at Christchurch, thus rendering untenable the tropical phenomenon hypothesis. Macquarie Island echoes, of a strength comparable with those from the normal regions, are

observed on most days of the year, usually appearing within an hour after ground sunrise and disappearing during the hour before sunset. On a few occasions each month echoes persist throughout the night. The maximum frequency at which echoes are received usually increases from less than 2 Mc./s. at first appearance to greater than 7·5 Mc./s. at noon and falling to less than 2 Mc./s. at disappearance. Strong *D*-echoes remain on occasions when, due to high absorption, no echoes are received from the normal daytime-occurring ionospheric regions.

As the only factor common to the five stations under discussion is that four are islands and the fifth is sited on a headland with sea on both sides, it appears possible that the effect may be peculiar to island observatories.

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Dec. 29.

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Meaning of Turnover in Biochemistry

In a recent communication, Kleiber[1] criticized the 'logic' of the term 'turnover-rate' used as an index of rate of synthesis, exchange, or appearance of some material[2]. He suggested that turnover-rate should properly refer only to the reciprocal of turnover time, that is, the fraction of a given metabolic pool renewed per unit of time.

Hevesy was among the first to investigate the quantitative aspects of isotope kinetics. He employed the term turnover-rate to denote the amount of material transferred per unit of time[3]. Many others have followed this usage[4–6]. An investigator may measure the rate of a metabolic process in terms of the fraction of the total metabolic pool renewed per hour; but it would be less confusing to designate this quantity by a term other than 'turnover-rate'. Kleiber[1] assumes that the use of 'turnover' in metabolic work arises from the analogy with the turnover of a wheel. However, this assumption may be unwarranted, for the early workers in the isotope field may have employed the analogy with the rapid turnover of patients in a well-organized hospital or the labour turnover-rate of an organization. This quantity may be expressed in terms of absolute turnover-rate (that is, the number of men entering or leaving the group), or as relative turnover-rate (the ratio of the absolute turnover-rate to the average working-force). Thus, there seems to be no *a priori* reason why the use of 'turnover-rate' should be restricted to the latter sense when dealing with metabolic processes. In our own work we have differentiated between (absolute) turnover-rates and fractional turnover-rates[7]. Reiner[6] has used relative turnover-rate for the latter. Considerable confusion may be anticipated if various investigators attach different definitions to standard terms.

In recognition of the importance of a clear-cut terminology in this field, and in keeping with present-day usage, I wish to propose the following definitions:

Turnover-rate. The quantity of material turned over per unit of time.

Fractional turnover-rate. The fraction of a given pool turned over per unit of time.

Turnover-time. The time required for the turnover of an amount of material equal to the pool size; this is the reciprocal of the fractional turnover-rate.

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March 19.

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[2] Zilversmit, D. B., Entenman, C., and Fishler, M. C., *J. Gen. Physiol.*, **26**, 325 (1943).
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Paper Chromatography of Inositol Phosphates

In the course of an examination of the organic phosphorus compounds in soils, a fraction was isolated rich in a substance resembling phytic acid, and which on hydrolysis yielded meso-inositol. Since lower phosphate esters of inositol may be present in soil, a chromatographic study has been carried out on the products obtained on partial hydrolysis of authentic phytin by acid, or by an enzyme method described by S. and T. Posternak[1].

Of the many solvent systems investigated, the best had the composition: 70 vols. methanol/30 vols. 0·5 *N* ammonium hydroxide. The hydrolysate was best applied in a small band to the paper, which had previously been washed thoroughly with dilute hydrochloric acid, water, ammonium versenate and water, in that order. Upward development was carried out at about 23° C., but the temperature was not rigidly controlled. Spots were detected by spraying with the molybdate – perchloric acid reagent of Hanes and Isherwood[2], and heating the papers between glass plates in an oven at 90° C. for 30 min.

Four spots were obtained from the hydrolysates, with the following R_F values:

		R_F
(1)	Inositol hexaphosphate	0·06
(2)	First intermediate ester(s)	0·17
(3)	Second intermediate ester(s)	0·32
(4)	Orthophosphate (+ probable third intermediate)	0·48

Resolution between the lowest two spots was not always absolute, depending upon the relative amounts of the two constituents present, but a clear demarcation could always be drawn between them. The spot with R_F value 0·17 is most likely to be the tetraphosphate, but work is being continued to establish the identity of the intermediates. There is evidence of a third intermediate, masked by the orthophosphate, and present in only very small amount even at advanced stages of hydrolysis.

Several inositol phosphates have been isolated by large-scale fractionation of phytic acid hydrolysates[1,3,4]; but no paper chromatographic method of separation appears to have been published. The

method is clearly a useful approach to a study of the phytin fraction in soils, particularly where extremely small quantities are present.

A complete account of this work and the application of the method in qualitative and quantitative studies of the inositol phosphates present in soils will be published elsewhere.

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Jan. 22.

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Earthworm Population Studies: a Comparison of Sampling Methods

In 1947, Evans and Guild[1] described a new technique for the quantitative extraction of earthworms. This consisted of treating a known area with a solution of potassium permanganate (1·5 gm. per litre) at the rate of 6·8 litres per sq. metre. The method was said to recover a high proportion of the total population and has, since the initial description, been extensively used by these authors[2].

I found, however, that population estimates obtained by the permanganate technique were considerably lower than those suggested when a more laborious hand-sorting method was employed. In order to measure the relative efficacy of these techniques, permanent pasture on light soil of alluvial origin was sampled by both methods contiguously. The tests were made during September 1954, at the Durham County Council School of Agriculture, Houghall Farm.

Permanganate sampling was carried out according to Evans and Guild[1], except that the sample area was increased from 7·29 sq. ft. to 1 sq. metre. Soil samples for hand-sorting were extracted by means of a steel scoop of semicircular cross-section. This cut a core 283 sq. cm. in area and 20 cm. deep, thus needing thirty-five to complete a square metre. In each of ten loci chosen at random over the site, a permanganate sample was taken; and in every case the treatment was repeated after an interval of two hours. Five soil cores were removed from the adjacent but unaffected area of each permanganate sample.

The results are shown in Table 1 as the average number of worms per locus and sq. metre. These

Table 1. Average Number of Worms per Locus and Square Metre

Species	First permanganate treatment. Av. No. per locus and sq. m.	Second permanganate treatment. Av. No. per locus and sq. m.	Soil cores Av. No. per locus	Soil cores Av. No. per sq. m.
Lumbricus terrestris	5·0 ± 2·8	9·1 ± 4·7	9·3 ± 1·3	65·1
Lumbricus castaneus	3·2 ± 2·1	2·8 ± 2·2	7·8 ± 2·9	54·6
Octolasium cyaneum	0·2 ± 0·6	0·5 ± 0·7	1·5 ± 1·2	10·5
Allolobophora terrestris	19·8 ± 4·6	8·3 ± 3·4	21·4 ± 5·0	149·8
Allolobophora caliginosa	5·2 ± 2·4	5·0 ± 2·6	11·1 ± 3·9	77·7
Eisenia rosea	1·6 ± 1·9	3·7 ± 3·4	12·8 ± 5·6	89·9
Total	35·0 ± 10·2	29·4 ± 9·8	63·9 ± 9·8	447·6

Table 2. Analysis of Variance. Snedecor's *F*

Species	Soil cores First permanganate treatment		Soil cores First and second permanganate treatments	
	Between treatments d.f. 1 : 9	Between samples d.f. 9 : 9	Between treatments d.f. 1 : 9	Between samples d.f. 9 : 9
Lumbricus terrestris	0·00	0·74	11·28†	0·99
Lumbricus castaneus	4·35	2·41	2·35	2·08
Octolasium cyaneum	2·86	0·90	4·20	3·06
Allolobophora terrestris	53·81†	1·46	16·33†	1·87
Allolobophora caliginosa	2·48	2·41	0·69	2·82
Eisenia rosea	61·66†	1·61	52·72†	4·41*

* Significant at the 5 per cent level. † Significant at the 1 per cent level

units are the same for the permanganate treatments but not for the soil cores, where the number per locus must be multiplied by 7 to estimate the number per sq. metre.

While the fifty soil cores, completing 1·43 sq. metres, produced 639·5 worms, the permanganate samples of 10 sq. metres produced only 350 worms. Thus it is abundantly clear that the permanganate technique gave an unsatisfactorily low population estimate, although of the same order as those of Evans and Guild[1,2].

To determine whether or not the techniques extracted similar species ratios, analyses of variance were calculated for treatment-pairs. The percentage of species per locus was used for this purpose and the results, as Snedecor's F [3], are given in Table 2.

In no case is there significant variance, at the 1 per cent level, between samples, which suggests an even distribution of the earthworm population and an intrinsic consistency of sampling method. Although all the techniques are consistent by themselves, they differ when compared with each other; and in three species significant variance occurs between treatments. Thus relative to the proportion from the soil cores, the first permanganate treatment produced more specimens of *Allolobophora terrestris* and fewer *Eisenia rosea* than expected. Conversely, the second permanganate treatment produced more specimens of *Lumbricus terrestris* and fewer *Eisenia rosea*. This correlation of effect with species is interesting in suggesting that potassium permanganate, in conjunction with a hand-sorting method, may be useful in determining the habits of different species.

The evidence discussed above shows that the permanganate method of sampling, used alone, is unsuitable for comparative population studies of earthworms.

I am indebted to Dr. B. M. Church, of Rothamsted, and Dr. E. S. Page, of the Durham Colleges, for their advice in the use of analyses of variance. The work was carried out while receiving a grant from the Nature Conservancy.

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Jan. 15.

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[3] Snedecor, G. W., "Statistical Methods" (Iowa State College Press, 1946).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 16

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. G. B. Brown: "Unification of Macroscopic Physics by Action-at-a-Distance".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. S. Romer (Harvard): "Texas Redbed Fossils and Vertebrate Evolution".*

UNIVERSITY OF LONDON (in the Chemistry Lecture Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. D. J. Cram (University of California): "Certain Problems in Large Ring Chemistry".*

Tuesday, May 17

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Sir R. E. Mortimer Wheeler: "Aspects of the Ascent of a Civilization" (Hobhouse Memorial Lecture).

WRIGHT-FLEMING INSTITUTE OF MICROBIOLOGY (at St. Mary's Hospital Medical School, London W.2), at 5 p.m.—Dr. A. T. R. Mattick: "The Lactobacilli and some Streptococci" (Almroth Wright Lecture).

Tuesday, May 17—Friday, May 20

TEXTILE INSTITUTE (at Caxton Hall, Caxton Street, London, S.W.1)—40th Annual Conference—"Practice and Progress in the Textile Industry".

Tuesday, May 17—Saturday, May 21

INSTITUTE OF METAL FINISHING (at the Palace Hotel, Torquay)—Annual Conference.

Wednesday, May 18

CHEMICAL SOCIETY (in the Department of Chemistry, The University, Leeds), at 10 a.m.—Symposium on "The Friedel-Crafts Reaction".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London W.C.2), at 2.30 p.m.—Sir Alexander Todd, F.R.S.: "Some Recent Developments in the Chemistry of Nucleic Acids" (Pope Memorial Lecture).

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2), at 3 p.m.—Miss K. Slack: "The Community's Responsibility for Special Groups—The Disabled and Old People". (Third of seven University Extension Lectures on "The Development and Pattern of the Social Services".)

PHYSICAL SOCIETY, COLOUR GROUP (in the Large Physics Theatre, Imperial College, Imperial Institute Road, South Kensington, London, S.W.7), at 3.30 p.m.—Address by Dr. D. B. Judd (National Bureau of Standards, Washington, D.C.); 5.30 p.m.—Dr. D. L. MacAdam (Eastman Kodak Company, U.S.A.): "Colour and Its Measurement".*

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. E. T. Pierce: (*a*) "Electrostatic Field-Changes due to Lightning Discharges"; (*b*) "The Development of Lightning Discharges"; Mr. R. F. Jones: "Radar Echoes from Lightning".*

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. A. J. Cruise: "Morphological Variants in Mammalian Connective Tissue Fibres".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. D. R. Coleman, Mr. D. A. Allanson and Mr. B. A. Horlcek: "The Development of the Underwater Television Camera".

Thursday, May 19

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 4 p.m.—Dr. C. M. Fletcher: "Atmospheric Pollution and Disease".*

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Prof. Sir Alfred Egerton, F.R.S.: "Scientific Research in India" (Thomas Holland Memorial Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Annual General Meeting. 6.30 p.m.—The Rt. Hon. Lord Citrine, P.C.: "Human Relations in Industry".

ROYAL AERONAUTICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Dr. C. S. Draper: "Flight Control" (43rd Wilbur Wright Memorial Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Prof. A. Corradetti: "Studies on Comparative Pathology and Immunology in Mammal and Bird *Plasmodium* Infections".

BRITISH INSTITUTE OF RADIOLOGY incorporated with the RÖNTGEN SOCIETY (at 32 Welbeck Street, London, W.1), at 8 p.m.—Annual General Meeting. 8.30 p.m.—Mr. J. A. C. Fleming: "Some Reflections on the Position and Scientific Role of the Institute" (Presidential Address).

Friday, May 20

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. H. C. Pritchard: "Automatic Dead Reckoning Instruments".

UNIVERSITY OF LONDON (at St. Thomas's Hospital Medical School, London, S.E.1), at 5 p.m.—Prof. V. Erspamer (Bari): "The Biological Significance of 5-hydroxytryptamine and Related Substances".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Sir Wilfrid Le Gros Clark, F.R.S.: "The Exposure of the Piltdown Forgery".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (with a degree in agriculture or equivalent qualification, sound experience in practical work, and preferably experience in teaching) IN AGRICULTURE, at the Cumberland and Westmorland Farm School, Newton Rigg, near Penrith—The Director of Education, 5 Portland Square, Carlisle (May 18).

LECTURER (with a good honours degree in physics, and preferably able to teach the subject to a high standard) IN PHYSICS—The Principal, Wigan and District Mining and Technical College, Wigan (May 19).

ASSISTANT CHEMIST (Fuel) (with H.N.C. in chemistry or equivalent, and experience associated with the sampling and analysis of fuel and related work) IN THE DIVISIONAL CHEMICAL LABORATORY, Leeds—The Divisional Secretary (Establishments), Central Electricity Authority, Yorkshire Division, Central Electricity House, St. Mary's Road, Leeds 7 (May 21).

ASSISTANT LECTURER (with special interests in the field of cartography) IN GEOGRAPHY—The Registrar, University College, Singleton Park, Swansea (May 21).

RESEARCH MICROBIOLOGIST (Scientific Officer grade) IN THE DOMESTIC FOOD PRESERVATION SECTION at the Long Ashton Research Station, Bristol—The Registrar and Secretary, The University, Bristol (May 21).

SENIOR LABORATORY TECHNICIAN, to be responsible for the physics laboratories and stores—The Secretary, Paddington Technical College, Saltram Crescent, London, W.9 (May 21).

ASSISTANT LECTURER IN BIOLOGY, ASSISTANT LECTURER IN BIOCHEMISTRY, and a SENIOR LECTURER or LECTURER IN THE DEPARTMENT OF VETERINARY PHYSIOLOGY—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1 (May 25).

UNIVERSITY LECTURER (with an appropriate honours degree and with experience of research and teaching) IN AGRICULTURAL MYCOLOGY—The Secretary, School of Agriculture, Downing Street, Cambridge (May 25).

ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, The University, Edinburgh (May 28).

LECTURER IN SOCIOLOGY in the Department of Social Anthropology—The Registrar, The University, Manchester 13 (May 28).

LECTURER IN THE FLUID MOTION LABORATORY, to work on problems of electronics and instrumentation for the measurement and observation of fluid flow, including turbulence, the propagation of shock waves and aerodynamic noise—The Registrar, The University, Manchester 13 (May 28).

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF BOTANY—The Registrar and Secretary, The University, Bristol 8 (May 28).

SENIOR LECTURER IN SOCIAL PSYCHOLOGY—The Secretary of University Court, The University, Glasgow (May 28).

ASSISTANTS IN THE DEPARTMENT OF CHEMISTRY—The Secretary, The University, Edinburgh (May 30).

STATISTICIAN (with a good honours degree or postgraduate diploma in statistics, or a good honours degree in mathematics with postgraduate experience in statistics) IN THE AGRICULTURAL RESEARCH COUNCIL'S UNIT OF STATISTICS attached to the Department of Statistics, University of Aberdeen—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (May 31).

PHYSICIST (with a good knowledge of classical physics and ability in application to process problems and machine design), for advanced research on mechanical and hydraulic systems for briquette manufacture now approaching the development stage—The National Coal Board, Central Research Establishment, Stoke Orchard, near Cheltenham, Glos, quoting TT/966 (June 1).

PROFESSOR OF MATHEMATICS, and a PROFESSOR OF CHEMISTRY—Dr. W. A. Jenkins, Vice-Chancellor, University of Dacca, c/o the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (June 1).

RESEARCH ASSISTANT IN THE DEPARTMENT OF APPLIED MATHEMATICS for theoretical work on upper atmosphere physics—Prof. D. R. Bates, F.R.S., Department of Applied Mathematics, Queen's University, Belfast (June 1).

ASSISTANT LECTURER IN PSYCHOLOGY—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (June 3).

ASSISTANT LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (June 4).

LECTURERS or ASSISTANT LECTURERS (3) IN PHYSICS—The Registrar, The University, Leeds 2 (June 4).

RESEARCH DEMONSTRATOR IN PHYSICS—The Registrar, The University, Sheffield (June 4).

SCIENTIST, Grade II (with a good honours degree or equivalent with the main qualification in chemistry, and preferably with experience in the analysis of solid fuels), on the staff of the Director of Scientific Control at London Headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/975 (June 4).

LECTURER IN PHILOSOPHY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 6).

ENDO-PARASITOLOGIST (with a university degree in science with zoology to an advanced stage and preferably with experience in the investigation of parasitology), at the Animal Research Station, Wallaceville, New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting 3/4/42 (June 7).

CHAIR OF BOTANY at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (June 10).

PROFESSOR OF BOTANY at the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Ceylon, June 15).

LECTURER, Grade II (with special interests in the philosophy of science, and preferably with a qualification in a natural science), IN PHILOSOPHY—The Registrar and Secretary, The University, Bristol (June 18).

RESEARCH ASSISTANT TO THE PROFESSOR OF FUEL TECHNOLOGY—The Registrar, The University, Sheffield (June 18).

RESEARCH FELLOW (preferably with experience in low energy nuclear physics, or photo disintegration problems) IN THE DEPARTMENT OF NUCLEAR PHYSICS, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (June 30).

SCIENTIFIC OFFICER (with a good honours degree in botany or agricultural botany and preferably with an interest in fruit culture and plant physiology), for work on the growth and development of soft fruits, mainly the raspberry; and an EXPERIMENTAL OFFICER (with a degree in horticulture or general biology, preferably with some training in genetics) to assist in soft fruit breeding—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee (June 30).

AGRICULTURAL OFFICER (with a university degree in agriculture or a related subject, and a sound knowledge of field experimentation with particular reference to techniques for grassland research, feeding trials and nutritional studies), at St. Ignatius Livestock Station, British Guiana, to undertake investigational and field work on pasture and fodder grasses and other crops suitable for the area—Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.63/30/03.

ANALYTICAL CHEMIST, Experimental Officer grade (preferably with a pass degree in chemistry, or at least H.S.C. (science) or equivalent), for research and development work in an analytical laboratory—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 629/WGE/34.

ASSISTANT LECTURER IN DAIRYING at the School of Agriculture, Sutton Bonington, near Loughborough—The Registrar, The University, Nottingham.

EXPERIMENTAL OFFICERS (preferably with a pass degree or at least H.S.C. (science) or equivalent), and ASSISTANT EXPERIMENTAL OFFICERS (with at least H.S.C. (science) or equivalent), for the design and application of pneumatic control systems mainly for the measurement of temperature and humidity—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 627/WGE/34.

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent qualification in electrical or mechanical engineering or physics), at the Ministry of Supply London Headquarters, to lead a section responsible for initiating and supervising research and development in design of aircraft flight instruments—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.274/5A.

SCIENTIFIC OFFICERS (with a first- or second-class honours degree in mathematics, physics or economics), for operational research in or near London, under the direction of the Scientific Adviser to the Air Ministry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.384/54.

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